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7th International Conference on Radionuclide Metrology Low-Level Radioactivity Measurement Techniques

ICRM

INTERNATIONAL COMMITTEE
FOR RADIONUCLIDE METROLOGY

CONFERENCE PROGRAM

26-30 SEPTEMBER 2016
Motif Hotel, Seattle, Washington, USA

http://llrmt2016.pnnl.gov | llrmt2016@pnnl.gov

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Welcome to LLRMT2016

The International Committee for Radionuclide Metrology (ICRM) welcomes you to the 7th Annual Conference on Radionuclide Metrology Low-Level Radioactivity Measurement Techniques (LLRMT2016), held at the Motif Seattle hotel in Seattle, Washington, USA from 26-30 September 2016.

LLRMT2016 brings together scientists from around the world to work on topics such as the development of low-background techniques, environmental monitoring, environmental science, treaty verification, and much more. LLRMT2016 is sponsored by the ICRM Low-Level Radioactivity Measurement Working Group and hosted by the Pacific Northwest National Laboratory (PNNL), which is managed by Battelle Memorial Institute for the U.S. Department of Energy. This year's conference is also the first time the event is being hosted in the United States. We hope you enjoy your visit to the city of Seattle, a leading innovation hub for research, science, and technology as well as a gem of the Pacific Northwest.

This year's conference features oral and poster presentations as well as a workshop on Metrology and Citizen Initiatives. After a structured peer review process, selected conference papers will be published in *Applied Radiation and Isotopes*, a refereed scientific journal. Additionally, conference attendees and accompanying guests are invited to participate in an optional Tillicum Village Cruise and Banquet to enjoy a cultural experience and cruise across the Puget Sound.

If you have questions during the event, LLRMT2016 committee staff will be available to assist you or you can contact llrmt2016@pnnl.gov and visit http://llrmt2016.pnnl.gov at any time.

Thank you for attending LLRMT2016 and please enjoy the conference!

International Committee for Radionuclide Metrology	Pacific Northwest National Laboratory
http://physics.nist.gov/ICRM	http://www.pnnl.gov

1.0 Conference Overview

LLRMT2016 is a five-day topical meeting packed with presentations and poster sessions as well as a workshop spanning the techniques, applications, and data in the field of low-level radioactivity measurement. Topics include but are not limited to ***low-level[1] aspects*** of the following:

- **Radiochemical Techniques:** Fission Products, Actinides, Activation Products, Long-Lived Radionuclides, Rapid Methods

- **Applications:** Naturally Occurring Radioactive Material (NORM), Decommissioning, Bioassay, Food Safety, Safeguards, Remediation, Emergency Response, Nuclear Forensics, Waste Management, Support Measurements for Astroparticle Physics, etc.

- **Radiometrics:** α-Particle Spectrometry, Liquid Scintillation Counting, 'Low-Level' and Ultra-Low-Level γ-Ray Spectrometry, Other Radiometric Techniques

- **Non-radiometric Measurements:** Mass Spectrometry – Inductively Coupled Plasma, Thermal Ionization, Accelerator Based, Neutron Activation

- **Radioactive Noble Gases:** Including the decay products of radon isotopes

- **Quality:** Traceability, Reference Materials, Proficiency Tests, Intercomparisons, Quality Assurance

- **Special Topics:**

  – **Monitoring Networks**: For this special session we focus on three monitoring network themes: **radiation safety monitoring networks**; **radiation portal monitors**, for example at border crossings to prevent nuclear smuggling; and **international networks for verification of nuclear treaties**, for example the International Monitoring System, which supports the Comprehensive Nuclear-Test-Ban Treaty.

  – **Metrology of NORM**: Low-level methods for quantifying NORM, development of Certified Reference Material for NORM, and the quantification of disequilibrium from industrial processes giving rise to TENORM.

  – **Metrology and Citizen Initiative Workshop**: The workshop will explore lessons learned from citizen science initiatives organized in response to Fukushima and other events and discuss factors that shape the ability of citizen science to influence scientists, decision-makers, and the public.

The event also features an optional social event on the afternoon of 28 September 2016.

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[1] Low-level radioactivity measurements generally deal with measurements of activity at Bq, or rather mBq-levels, or with techniques to pre-concentrate radionuclides such that extremely small concentrations (e.g., microBq/kg or lower) can be measured.

2.0   Scientific Committee

- Craig Aalseth, PNNL, ICRM-LLRMT 2016 Lead Guest Editor, USA
- Dirk Arnold, PTB, ICRM Chairperson, Germany
- Arvic Harms, IAEA, International
- Matthias Auer, CTBTO, International
- Ljudmila Benedikt, IJS, Slovenia
- Michel Bruggeman, SCK, Belgium
- Philippe Cassette, CEA-LNHB, France
- Teresa Crespo, CIEMAT, Spain
- Matt Douglas, PNNL, USA
- Pierino de Felice, ENEA, Italy
- Ryan Fitzgerald, NIST, USA
- Eduardo Garcia Torano, CIEMAT, Spain
- Robert K. Hague, INL, USA
- John Hardy, Texas A&M University, USA
- Yoshio Hino, NMIJ, Japan
- Mikael Hult, EC-JRC-Geel, EU
- Simon Jerome, NPL, UK
- Karsten Kossert, PTB, Germany
- Matthias Laubenstein, INFN-LNGS, Italy
- Sang-Han Lee, KRISS, Korea
- Marie-Christine Lepy, CEA-LNHB, France
- Franz-Josef Maringer, BEV, Austria
- Iolanda Osvath, IAEA, International
- Tae Soon Park, KRISS, Korea
- Pavel Povinec, Comenius University, Slovakia
- Guy Ratel, BIPM, International
- Peter Santschi, Texas A&M University, USA
- Clemens Schlosser, BfS, Germany
- Octavian Sima, University of Bucharest, Romania
- Freda Van Wyngaardt, ANSTO, Australia
- Dawn Wellman, PNNL, USA
- Herbert Wershofen, PTB, Germany
- Richard Williams, PNNL, USA
- Akira Yunoki, NMIJ/AIST, Japan
- Brian Zimmerman, NIST/Elsevier, USA

3.0   Organizing Committee

- Jill Brandenberger, PNNL, Co-Chair
- Allen Seifert, PNNL, Co-Chair
- Mikael Hult, EC-JRC-Geel
- Craig Aalseth, PNNL
- Blake Wright, PNNL
- Maren Disney, PNNL
- Sharon Eaton, PNNL
- Cheryl Freshley, PNNL
- David Hachigian, PNNL
- Shannon Osborn, PNNL

4.0 Schedule

The scientific program overview for the 2016 LLRMT Conference is provide below and also accessible online at http://llrmt2016.pnnl.gov.

2016 ICRM Low-Level Radioactivity Measurements Techniques Conference
Scientific Program

	Sun - 9/25	Mon - 9/26	Tues - 9/27	Wed - 9/28	Thurs - 9/29	Fri - 9/30
8:00		Registration & Poster Setup	Registration	Registration	Registration	Registration
9:00			Non-radiometric Measurements III	Radiometrics I	Radiochemical Techniques	Quality I
10:00		Opening Ceremony	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:00		Radioactive Noble Gases	Applications I	Radiometrics II	Special Session: Monitoring Networks I	Quality II
12:00		Lunch	Lunch	Lunch	Lunch	Lunch
13:00						
14:00		Non-radiometric Measurements I	Applications II	Radiometrics III	Special Session: Monitoring Networks II	Special Session: Metrology of NORM
15:00		Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
					Coffee Break	Closing Ceremony
16:00		Non-radiometric Measurements II	Applications III	Tillicum Village	Metrology and Citizen Initiatives Workshop	Remove Posters
17:00	Registration	Reception	Group Photography			
18:00						
19:00	Informal Gathering					
20:00						
21:00						

5.0   Social Events

On 28 September 2016, conference participants and guests are invited to experience the tribal culture of the Northwest with an optional Tillicum Village Cruise and Banquet. The 4-hour excursion departs from Pier 55 to the historic Blake Island, the legendary birthplace of Chief Seattle, for whom the city is named. The trip includes a 45-minute cruise on Puget Sound to Tillicum Village and a live performance featuring traditional song and dance and delight in a delicious salmon buffet. The cost is $85 USD per person at the time of registration. The ticket includes a cruise from Puget Sound out to Blake Island followed by a traditional salmon dinner and Native American entertainment. Figure 1 provides walking directions from the conference venue to the launch point. Boarding begins at 4:00 pm PST and all passengers must be loaded by 4:15 pm PST.
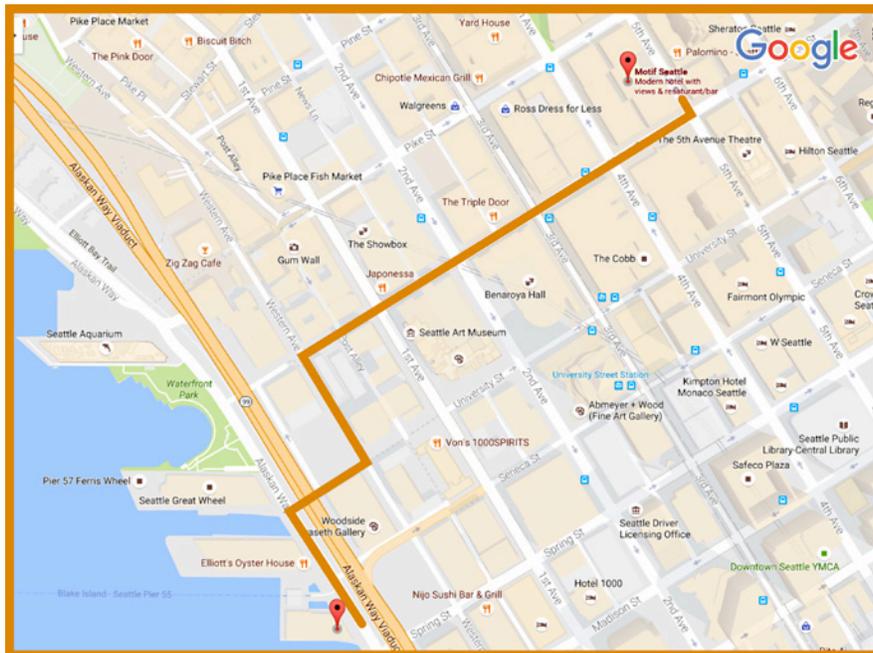

Figure 1.   Walking directions from the conference venue to the launch point for the Tillicum Village Cruise and Banquet

6.0   Local Area Information

LLRMT2016 is hosted at the Motif Seattle hotel, located in downtown Seattle and within walking distance of popular attractions. While in Seattle, participants can take advantage of the proximity to great performing arts venues by seeing a Broadway show at the famed Paramount or a concert at the engineering marvel that is Benaroya Hall. At the celebrated waterfront, shop or enjoy a meal at the bustling Pike Place market, ride on the giant Ferris wheel, or enjoy a ferry ride across the Sound to the lush Olympic Peninsula or San Juan Islands. Walk around town and take the Space Needle tour, and peruse one of the many excellent museums, from the famed Asian Art Museum to the otherworldly Chihuly Garden and Glass to the Pacific Science Center and IMAX Theatre.

Parking is available at the Motif Seattle as well as nearby at the following locations:

Washington Athletic Club – entrance at 1409 6th Avenue

- Hours: 24 Hrs
- Early Bird Special: Arrive 5AM – 8:59AM / Max 10 hours = $20.50
- Evening Special: Arrive after 5PM / Leave by 5AM = $7.00
- Max parking rate = $35.00

Sheraton – entrance at 1411 6th Avenue

- Hours: 24 Hrs
- 1 hour = $16.00, 5 hours = $39.00, 24 hours = $57.00

Fairmont Olympic Hotel – entrance at 411 University Street

- Hours: 24 Hrs
- 1 hour = $15.00, 6 hours = $37.00, 12 hours = $45.00, 24 hours = $55.00

Hilton Seattle Garage – entrance at 1301 6th Avenue

- Hours: 24 Hrs
- Early Bird Special: Arrive 6AM – 8:59AM / Max 10 hours = $18.00
- Evening Special: Arrive 5PM – Midnight / Max 6 hours = $8.00
- Max parking rate = $43.00

Pike Tower Garage – entrance at 520 Pike Street

- Hours: Mon-Sun – 5AM – Midnight
- Early Bird Special: Arrive 5AM – 8:59AM / Max 11 hours = $16.00
- Evening Special: Arrive after 4PM / Leave by Midnight = $7.00
- Max parking rate = $35.00

Puget Sound Plaza / Cobb Garage – entrance at 315 Union Street or 324 University Street

- Hours: Mon-Fri – 6AM – Midnight, Sat – 7AM – Midnight; (closed Sundays and Holidays)
- Early Bird Special: Arrive 6AM – 8:59AM / Leave by 6 PM = $18.00
- Evening Special: Arrive after 5PM / Leave by Midnight = $8.00

Rainer Square – entrance at 409 Union Street (Closed holidays)

- Hours: Mon-Fri – 6AM – Midnight, Sat – 7AM – Midnight, Sun – 9AM – Midnight
- Evening Special: Arrive after 5PM / Leave by Midnight = $9.00
- Max parking rate = $40.00

US Bank Centre – entrance at 1465 6th Avenue or 550 Union Street (Closed holidays)

- Hours: Mon-Thur – 6:30PM – 11:30PM, Fri – 6:30AM – 12:30AM, Sat – 8:30AM – 12:30AM, Sun – 9AM – 11:30PM
- Early Bird Special: Arrive 6:30AM – 9:29AM / 10 hours max = $16.00
- Evening Special: Arrive after 5PM / Leave by closing = $7.00
- Max parking rate = $35.00

Meridian Parking Garage – entrance at 634 Pike Street

- Hours: Mon-Thur – 6AM – 1AM, Fri – 6AM – 3AM, Sat – 8AM – 3AM, Sun – 8AM – 1AM
- Early Bird Special: Arrive 6AM – 9:59AM / Max 12 hours = $14.00
- Evening Special: Arrive after 4PM / Leave by closing = $6.00
- Max parking rate = $30.00

Century Square Garage – entrance at 400 Pike Street

- Hours: Mon-Thur – 7AM – 1AM, Fri – 7AM – 2AM, Sat – 9AM – 2AM, Sun 10AM – 1AM
- Early Bird Special: Arrive 7AM – 8:59AM / Max 10 hours = $16.00
- Evening Special: Arrive after 5PM / Leave by closing = $7.00

ICRM - Low-Level Radioactivity Measurement Techniques (LLRMT) 2016

Monday 26 September 2016

Registration & Poster Setup (08:00-10:00)

Opening Ceremony (10:00-10:40)

- **Conveners: Ms. Brandenberger, Jill (Pacific Northwest National Laboratory)**

time	[id] title	presenter
10:00	[173] ICRM Welcome	Dr. ARNOLD, Dirk (Physikalisch-Technische Bundesanstalt)
10:05	[174] LLMT Welcome	Dr. HULT, Mikael (EC-JRC-IRMM)
10:10	[175] PNNL Welcome	PEURRUNG, Anthony (Pacific Northwest National Laboratory)
10:15	[176] LLRMT '16 Scientific "Encouragement"	Dr. AALSETH, Craig (Pacific Northwest National Laboratory)
10:20	[177] LLRMT '16 Logistics	Dr. SEIFERT, Allen (Pacific Northwest National Laboratory)

Radioactive Noble Gases (10:40-12:00)

- **Conveners: Dr. Back, Henning (Pacific Northwest National Laboratory); Dr. Park, Tae Soon (KRISS)**

time	[id] title	presenter
10:40	[85] Monte Carlo simulation of air sampling methods for the measurement of radon decay products	Prof. SIMA, Octavian (Physics Department, University, Romania)
11:00	[71] Methods for Using Argon-39 to Age-Date Groundwater using Ultra-Low-Background Proportional Counting	Dr. AALSETH, Craig (Pacific Northwest National Laboratory)
11:20	[45] Study about the radionuclides implanted on glass surfaces for the estimation of retrospective indoor radon concentrations	Prof. MARTIN SANCHEZ, Alejandro (University of Extremadura (Spain))
11:40	[83] STATE OF THE ART ANALYSIS OF RADIOXENONS AND KRYPTON-85 AT THE BFS NOBLE GAS LABORATORY	Dr. SCHLOSSER, Clemens (Ferderal Office for Radiation Protection, Germany)

Radioactive Noble Gases: Poster Introduction - (12:00-12:20)

- **Conveners: Dr. Back, Henning (Pacific Northwest National Laboratory); Dr. Park, Tae Soon (KRISS)**

time	[id] title	presenter

12:00	[185] Radioactive Noble Gases Poster Introduction	Dr. BACK, Henning (Pacific Northwest National Laboratory) Dr. PARK, Tae Soon (KRISS)
12:01	[91] Continuous measurement of radon exhalation rate from soil surface around active volcano	Dr. HOSODA, Masahiro (Hirosaki University)
12:02	[123] Radon removal system for the LZ Dark Matter experiment	PUSHKIN, Kirill (University of Michigan)
12:04	[164] Improved Pressurized Marinelli Beaker Measurements of Radioactive Xenon in Air	Dr. ROBINSON, Troy (Idaho National Laboratory)
12:06	[149] Radon Emanation Screening for LZ	Mr. MILLER, Eric (South Dakota School of Mines)
12:08	[46] When the mean value does not mean what is really happening: The case of indoor radon concentration measured with track detectors in working places	Prof. MARTIN SANCHEZ, Alejandro (Department of Physics. University of Extremadura)
12:10	[49] Natural radon reduction rate of the Community Groundwater System in South Korea	Dr. CHO, Byong-Wook (LIGAM)

Lunch - (12:20-13:40)

Non-radiometric Measurements: Session 1 (13:40-15:00)

- **Conveners: Dr. Williams, Richard (Pacific Northwest National Laboratory); Douglas, Matthew (Pacific Northwest National Laboratory)**

time	[id] title	presenter
13:40	[105] Analysis of radionuclides at ultra low levels: synergy of low and high-energy mass spectrometry with gamma-spectrometry	Prof. POVINEC, Pavel (Comenius University)
14:00	[100] ICP MS measurements of ultra low-level radioactivity in solid material and comparison with γ-spectrometry within the CUPID experiment	Dr. DI VACRI, Maria Laura (INFN-LNGS)
14:20	[132] Rapid low-level analysis of 226Ra in groundwater samples by latest generation triple quadrupole ICP-MS	Ms. VAN ES, Elsje (University of Surrey)
14:40	[131] Development of an optimised method for analysis of strontium-90 in decommissioning wastes by triple quadrupole inductively coupled plasma mass spectrometry	Dr. RUSSELL, Ben (National Physical Laboratory)

Non-radiometric Measurements: Session 1 Poster Introduction - (15:00-15:20)

- **Conveners: Dr. Williams, Richard (Pacific Northwest National Laboratory); Douglas, Matthew (Pacific Northwest National Laboratory)**

time	[id] title	presenter
15:00	[186] Non-radiometric Measurements Session 1 Poster Introduction	Dr. WILLIAMS, Richard (Pacific Northwest National Laboratory) DOUGLAS, Matthew (Pacific Northwest National Laboratory)
15:01	[151] Isotopic Analysis of Plutonium in Foods by Inductively-Coupled Plasma Mass Spectrometry	Ms. EMANUELE, Kathryn (U.S. Food and Drug Administration)

Coffee Break (15:20-15:50)

Non-radiometric Measurements: Session 2 (15:50-16:50)

  - **Conveners: Douglas, Matthew (Pacific Northwest National Laboratory); Dr. Benedik, Ljudmila (Jožef Stefan Institute)**

time	[id] title	presenter
15:50	[58] Reference Materials for Neptunium Determination	Mr. JEROME, Simon (National Physical Laboratory)
16:10	[136] Application of Δ14C and δ13C to trace sources of organic carbon in Baltic Sea sediments	Dr. LUJANIENE, Galina (SRI Center for Physical Sciences and Technology, Vilnius, Lithuania)
16:30	[163] A comparative study of 129I content in environmental standard materials IAEA-375, NIST-4354 and NIST-4357 by Thermal Ionization Mass Spectrometry and Accelerator Mass Spectrometry	Dr. WATROUS, Matthew (Idaho National Laboratory)

Non-radiometric Measurements: Session 2 Poster Introduction - (16:50-17:00)

  - **Conveners: Douglas, Matthew (Pacific Northwest National Laboratory); Dr. Benedik, Ljudmila (Jožef Stefan Institute)**

time	[id] title	presenter
16:50	[187] Non-radiometric Measurements Session 2 Poster Introduction	DOUGLAS, Matthew (Pacific Northwest National Laboratory) Dr. BENEDIK, Ljudmila (Jožef Stefan Institute)
16:51	[127] Accurate measurement 234U/238U activity ratio and 236U/238U isotope ratio measurement in 10-8 range using thermal ionization mass spectrometry	Dr. SAHOO, Sarata Kumar (National Institute for Quantum and Radiological Science and Technology)
16:52	[107] Radiocarbon concentration in the atmosphere and in tree rings in the south-west Slovakia	Prof. POVINEC, Pavel (Comenius University)

Reception (17:00-19:00)

Registered participants are invited to a hosted reception featuring appetizers, wine, beer, and non-alocholic beverages in the foyer of the 4th floor from 17:00-19:00 on 26 September 2016.

Tuesday 27 September 2016

Registration (08:00-09:00)

Non-radiometric Measurements: Session 3 (09:00-10:00)

- **Conveners: Prof. Povinec, Pavel (Comenius University, Department of Nuclear Physics); Mr. Jerome, Simon (National Physical Laboratory)**

time	[id] title	presenter
09:00	[115] High Radiopurity Polymer Materials and Their Assay for Ultra Low Background Detector Applications	Dr. GRATE, Jay (Pacific Northwest National Laboratory)
09:20	[95] A Novel Methodology for the Ultratrace Determination of Uranium and Thorium in Polymer Materials	Dr. ARNQUIST, Isaac (Pacific Northwest National Laboratory)
09:40	[161] Laser Ablation Mass Spectroscopy of Polyethylene for U	Prof. BLISS, Mary (PNNL)

Non-radiometric Measurements: Session 3 Poster Introduction - (10:00-10:20)

- **Conveners: Prof. Povinec, Pavel (Comenius University, Department of Nuclear Physics); Mr. Jerome, Simon (National Physical Laboratory)**

Coffee Break (10:20-10:40)

Applications: Session 1 (10:40-12:00)

- **Conveners: Dr. Park, Tae Soon (KRISS); Dr. Arnold, Dirk (Physikalisch-Technische Bundesanstalt)**

time	[id] title	presenter
10:40	[44] Detection and assessment of specific natural organic compounds as carriers for radionuclides (e.g., I, Pu) in soil and water environments at ambient concentrations	Prof. SANTSCHI, Peter H. (Texas A&M University at Galveston)
11:00	[73] Improvements to sample processing and measurement to enable more widespread environmental application of tritium measurements	MORAN, James (Pacific Northwest National Laboratory)
11:20	[61] Residual radioactivity of treated green diamonds	Dr. CASSETTE, Philippe (CEA/LNHB)

Applications: Session 1 Poster Introduction - (12:00-12:20)

- **Conveners: Dr. Park, Tae Soon (KRISS); Dr. Arnold, Dirk (Physikalisch-Technische Bundesanstalt)**

time	[id] title	presenter
12:00	[188] Applications Session 1 Poster Introduction	Dr. PARK, Tae Soon (KRISS) Dr. ARNOLD, Dirk (Physikalisch-Technische Bundesanstalt)
12:01	[54] Monte Carlo optimization of shielding for novel industrial free-release measurement facility	Dr. SOLC, Jaroslav (Czech Metrology Institute)

| 12:02 | [160] Rapid Detection of Processed Uranium in Food | Dr. SHAREEF, Abdur-Rafay Shareef (US FDA) |
| 12:04 | [89] Measurement system of alpha and beta emitters with continuous air sampling under different exposure situations | Prof. TOKONAMI, Shinji (Hirosaki University) |

Lunch - Seattle Ballroom 1 (12:20-13:40)

Applications: Session 2 (13:40-15:00)

- Conveners: Dr. Wellman, Dawn (PNNL); Dr. Laubenstein, Matthias (L.N.G.S.-I.N.F.N.)

time	[id] title	presenter
13:40	[118] Re-circulation of FNPP1 derived radiocaesium observed in winter 2015/2016 at coastal region in Japan	Prof. AOYAMA, Michio (Institute of Environmental Rdioactivity, Fukushima Univ.)
14:00	[87] Intrusion of Fukushima-derived radiocesium into the Arctic Ocean from the Bering Sea in summer 2014	Dr. KUMAMOTO, Yuichiro (Japan Agency for Marine-Earth Science and Technology)
14:20	[114] Screening test for radioactivity on self consumption products in Fukushima after the Fukushima dai-ichi NPP accident in Japan	Dr. YAMADA, Takahiro (Japan Radioisotope Association)
14:40	[104] Long-term environmental radioactive contamination of Europe due to the Chernobyl accident - Results of the ICPDR Joint Danube Survey 2013 radioactivity measurements	Prof. MARINGER, Franz Josef (BEV - Federal Office for Metrology and Surveillance)

Applications: Session 2 Poster Introduction (15:00-15:20)

- Conveners: Dr. Wellman, Dawn (PNNL); Dr. Laubenstein, Matthias (L.N.G.S.-I.N.F.N.)

time	[id] title	presenter
15:00	[189] Applications Session 2 Poster Introduction	Dr. WELLMAN, Dawn (PNNL) Dr. LAUBENSTEIN, Matthias (L.N.G.S.-I.N.F.N.)
15:01	[98] A detector for radionuclide monitoring in water systems	Mr. DRINHAUS, Jorrit (Karlsruhe Institute of Technology)
15:02	[59] Environmental radioactivity study of forest ecosystems: long-term behaviour of contamination of wild boar and its radioecological coherences	Ms. KOCADAG, Maria (Technical University of Vienna (TU Wien), Vienna, Austria)
15:04	[64] Underground measurements of artificial radioactivity in squids from the western Pacific Ocean	Mr. MI, YuHao (Department of Engineering Physics, Tsinghua University)

Coffee Break (15:20-15:50)

Applications: Session 3 (15:50-17:10)

- Conveners: Dr. Laubenstein, Matthias (L.N.G.S.-I.N.F.N.); Prof. Maringer, Franz Josef (BEV - Federal Office for Metrology and Surveillance)

time	[id] title	presenter
15:50	[109] Mazinger, a gamma-ray spectrometry system of high efficiency and very low background for paloeoclimate applications	Dr. QUINTANA, Begoña (University of Salamanca)
16:10	[35] Coordinated underground measurements of gamma-ray emitting radionuclides for plasma physics research	Dr. HULT, Mikael (EC-JRC-Geel)
16:30	[170] ULBS, CES and Environmental Measurements at Laboratorio Subterráneo de Canfranc (LSC)	Ms. BORJABAD SÁNCHEZ, Silvia (Laboratorio Subterráneo de Canfranc (LSC))
16:50	[145] Black Hills State University Underground Campus	Dr. MOUNT, Brianna (BHSU)

Applications: Session 3 Poster Introduction (17:10-17:30)

- Conveners: Dr. Laubenstein, Matthias (L.N.G.S.-I.N.F.N.); Prof. Maringer, Franz Josef (BEV - Federal Office for Metrology and Surveillance)

time	[id] title	presenter
17:10	[190] Applications Session 3 Poster Introduction	Dr. LAUBENSTEIN, Matthias (L.N.G.S.-I.N.F.N.) Prof. MARINGER, Franz Josef (BEV - Federal Office for Metrology and Surveillance)
17:12	[155] Determination of Fixed Radioactivity in LZ detector components	Ms. OLIVER-MALLORY, Kelsey (Lawrence Berkeley National Laboratory and University of California Berkeley)
17:14	[146] COMPUTATIONAL APPROACHES ON PHOTON-ATTENUATION AND COINCIDENCE-SUMMING CORRECTIONS FOR THE DETECTION OF GAMMA-EMITTING RADIONUCLIDES IN FOODS	Dr. ROLLE, Clarence (Food and Drug Administration)

Group Photography (17:30-18:00)

Wednesday 28 September 2016

Registration (08:00-09:00)

Radiometrics: Session 1 (09:00-10:00)

  - **Conveners: Prof. Sima, Octavian (Physics Department, University of Bucharest, Romania); Dr. García-Toraño, Eduardo (CIEMAT)**

time	[id] title	presenter
09:00	[129] Characterization and calibration of a novel detection system for real time monitoring of radioactive contamination in water processed at water treatment facilities	Dr. DE FELICE, Pierino (ENEA)
09:20	[78] Efficiency computation for gamma-ray spectrometry assessment of samples with intrinsic inhomogeneity	Prof. SIMA, Octavian (Physics Department, University of Bucharest, Romania)
09:40	[82] The BiPo-3 detector	Dr. LOAIZA, Pia (Laboratoire de l'Accelerateur Lineaire, LAL, CNRS)

Radiometrics: Session 1 Poster Introduction - (10:00-10:20)

  - **Conveners: Prof. Sima, Octavian (Physics Department, University of Bucharest, Romania); Dr. García-Toraño, Eduardo (CIEMAT)**

time	[id] title	presenter
10:00	[191] Radiometrics Session 1 Poster Introduction	Prof. SIMA, Octavian (Physics Department, University of Bucharest, Romania) Dr. GARCÍA-TORAÑO, Eduardo (CIEMAT)
10:01	[76] Photon emission intensities in the decay of U-235	Dr. LEPY, Marie-Christine (CEA/LNHB)
10:02	[166] Uncertainties in Monte Carlo calculated correction factors for true coincidence summations (TCS)	Dr. KASTLANDER, Johan (Swedish Defence Research Agency (FOI))
10:04	[93] Simulation of well type HPGe detector for samples both in the hole and on the top of the endcap	Dr. UNNO, Yasuhiro (National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology)
10:06	[110] Absolute peak-efficiency calibration of a well-type germanium detector using multiple gamma-emitting nuclides with the iteration algorithm based on maximum likelihood estimation	Mr. ISHIZU, HIDETAKE (Japan Radioisotope Association)
10:08	[67] Mathematical vs classical efficiency calibration in routine measurements of gamma emitting radionuclides in environmental samples	Dr. TUCAKOVIC, Ivana (Ruder Boskovic Institute, Zagreb)

Coffee Break (10:20-10:40)

Radiometrics: Session 2 (10:40-12:00)

 - **Conveners: Dr. HINO, Yoshio (NMIJ/AIST); Dr. LEPY, Marie-Christine (CEA/LNHB)**

time	[id] title	presenter
10:40	[121] An integrated bubbler-LSC for on-line measurements of gaseous tritium and carbon-14	Dr. BELL, Steven (National Physical Laboratory)
11:00	[116] Studies of surface and bulk Po-210 in metals	Dr. ZUZEL, Grzegorz (Institute of Physics, Jagiellonian University)
11:20	[125] Design, Contruction, and Performance of a New Low-Background, External Source Gas Proportional Counter for Environmental Sample Measurements	Dr. KEILLOR, Martin (Pacific Northwest National Laboratory)
11:40	[70] Operational and Simulated Background Characterization of an Ultra-Low Background Liquid Scintillation Counter	Ms. ERCHINGER, Jennifer (Pacific Northwest National Laboratory)

Radiometrics: Session 2 Poster Introduction - (12:00-12:20)

 - **Conveners: Dr. HINO, Yoshio (NMIJ/AIST); Dr. LEPY, Marie-Christine (CEA/LNHB)**

time	[id] title	presenter
12:00	[192] Radiometrics Session 2 Poster Introduction	Dr. HINO, Yoshio (NMIJ/AIST) Dr. LEPY, Marie-Christine (CEA/LNHB)
12:01	[72] Simultaneous, Dual-Isotope Measurement Approaches for Tritium and Radiocarbon by Ultra-Low-Background Proportional Counting	MACE, Emily (Pacific Northwest National Laboratory)
12:02	[147] Small Volume Assay Method for 210Pb/Po in Lead	Ms. MORLEY, Shannon (Pacific Northwest National Laboratory)
12:04	[156] Development of a windowless multiwire proportional counting (MWPC) system for the measurements of the surface emission rate of alph- and beta- area sources	Dr. HWANG, Sanghoon (Korea Research Institute of Standards and Science)

Lunch (12:20-13:40)

Radiometrics: Session 3 (13:40-14:40)

 - **Conveners: Dr. Cassette, Philippe (CEA/LNHB); Dr. Hult, Mikael (EC-JRC-IRMM)**

time	[id] title	presenter
13:40	[124] Design and Performance of an Ultra-Low Background Cryostat for High-Purity Germanium Spectrometers	Dr. HOSSBACH, Todd (Pacific Northwest National Laboratory)
14:00	[40] Leda: a new low level spectrometer using gamma-gamma coincidence	Dr. DE VISMES OTT, Anne (IRSN)
14:20	[122] Calibration of a Low Background Gamma Spectrometer for the Assay of Pb-210 in Lead and Comments on Current Availability of Low Background Lead in North America	Dr. KEILLOR, Martin E (Pacific Northwest National Laboratory)

Radiometrics: Session 3 Poster Introduction - (14:40-15:00)

- Conveners: Dr. Cassette, Philippe (CEA/LNHB); Dr. Wershofen, Herbert (Physikalisch-Technische Bundesanstalt)

time	[id] title	presenter
14:40	[193] Radiometrics Session 3 Poster Introduction	Dr. CASSETTE, Philippe (CEA/LNHB) Dr. HULT, Mikael (EC-JRC-IRMM)
14:41	[106] Monte Carlo simulations of background characteristics of Ge detectors operating in the Gran Sasso underground laboratory	Prof. POVINEC, Pavel (Comenius University in Bratislava)
14:42	[108] A Second-generation Low-Background Gamma-Ray Spectrometer	Dr. LINDSTROM, Richard (National Institute of Standards and Technology)
14:44	[141] Digital gamma-gamma coincidence HPGe system for environmental analysis	Mr. MARKOVIC, Nikola (Center for Nuclear Technologies, Technical University of Denmark)
14:46	[36] Development of a dual-HPGe low background gamma-gamma coincidence/anticoincidence spectrometer	Dr. ZHANG, Weihua (Radiation Protection Bureau of Health Canada)
14:48	[66] GAMMA3: latest improvements and coincidence measurements	Dr. CAGNIANT, Antoine (CEA/DAM/DIF)
14:50	[57] The Dortmund Low Background Facility	Mr. NITSCH, Christian (TU Dortmund, Experimentelle Physik IV)

Coffee Break (15:00-16:00)

Tillicum Village (16:00-21:00)

Thursday 29 September 2016

Registration (08:00-09:00)

Radiochemical Techniques (09:00-10:00)

- **Conveners: Mr. Jerome, Simon (National Physical Laboratory); Dr. Benedik, Ljudmila (Jožef Stefan Institute)**

time	[id] title	presenter
09:00	[62] Development of radiochemical analysis strategies for decommissioning activities	Dr. ZAPATA-GARCÍA, Daniel (Physikalisch-Technische Bundesanstalt, PTB)
09:20	[69] Analysis of ultra-trace concentration of americium in sediments by HR-ICP-MS following a simple extraction chromatography separation	Mr. JOUINI, Ameur (Subatech, UMR 6457, Nantes, France)
09:40	[50] DETERMINATION OF LOW LEVEL NP-237 BY VARIOUS TECHNIQUES	Prof. BENEDIK, Ljudmila (Jožef Stefan Institute, Ljubljana, Slovenia)

Radiochemical Techniques: Poster Introduction - (10:00-10:20)

- **Conveners: Mr. Jerome, Simon (National Physical Laboratory); Dr. Wershofen, Herbert (Physikalisch-Technische Bundesanstalt)**

time	[id] title	presenter
10:00	[194] Radiochemical Techniques Poster Introduction	Mr. JEROME, Simon (National Physical Laboratory) Dr. BENEDIK, Ljudmila (Jožef Stefan Institute)
10:01	[152] Analysis of Radioactive Strontium in Food by Cerenkov Liquid Scintillation Counting	Ms. HEALEY, Stephanie (U.S. Food and Drug Administration)
10:02	[102] Combination of automated chromatographic separation and off-line Cherenkov counting in determination of low level activity of Sr-90.	Dr. GRAHEK, Željko (Ruder Boškovic Institute) Dr. IVANA, Tucakovic (Ruder Boškovic Institute)
10:04	[65] Application of thermogravimetric analysis for a high temperature combustion method of tritium analysis	KIM, Chang-Jong (Korea Atomic Energy Research Institute)

Coffee Break (10:20-10:40)

Special Session: Monitoring Networks: Session 1 (10:40-12:00)

- **Conveners: Prof. Maringer, Franz Josef (BEV - Federal Office for Metrology and Surveillance); Dr. Keillor, Martin (Pacific Northwest National Laboratory)**

time	[id] title	presenter
10:40	[171] INVITED TALK: Repurposing Existing Portal Monitor Infrastructure	Dr. LIVESAY, Ronald J. (Mason Livesay Scientific)

11:00	[126] INVITED TALK: Our Radioactive Ocean- establishing an ocean monitoring network after Fukushima	BUESSELER, Ken (Woods Hole Oceanographic Institution)
11:20	[167] Developing capacity for rapid response in the network of Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA)	Dr. OSVATH, Iolanda (IAEA)
11:40	[48] COMPACT RADIOACTIVE AEROSOL PARTICULATE MONITORING DEVICE FOR EARLY WARNING NETWORKS	Mrs. GLAVIC-CINDRO, Denis (Jožef Stefan Institute, Ljubljana, Slovenia)

Special Session: Monitoring Networks: Session 1 Poster Introduction - (12:00-12:20)

- **Conveners: Prof. Maringer, Franz Josef (BEV - Federal Office for Metrology and Surveillance); Dr. Keillor, Martin (Pacific Northwest National Laboratory)**

time	[id] title	presenter
12:00	[195] Special Session Monitoring Networks Session 1 Poster Introduction	Prof. MARINGER, Franz Josef (BEV - Federal Office for Metrology and Surveillance) Dr. KEILLOR, Martin (Pacific Northwest National Laboratory)
12:01	[112] Low-level atmospheric radioactivity measurement using a NaI(Tl) spectrometer during aerosol sampling	Mr. HYZA, Miroslav (SURO)
12:02	[119] Evaluation of an early warning system for airborne radionuclides	Dr. KASTLANDER, Johan (Swedish Defence Research Agency (FOI))

Lunch (12:20-13:40)

Special Session: Monitoring Networks: Session 2 (13:40-15:20)

- **Conveners: Dr. Aalseth, Craig (Pacific Northwest National Laboratory); Prof. Povinec, Pavel (Comenius University, Department of Nuclear Physics)**

time	[id] title	presenter
13:40	[168] INVITED TALK: The potential detection of low level aerosol isotopes from new civilian nuclear processes	Dr. MILEY, Harry (Pacific Northwest National Laboratory)
14:00	[94] Silicon PIN diode based electron-gamma coincidence detector system for Noble gases monitoring	Mr. KHRUSTALEV, Kirill (KKey NGneering Service)
14:20	[52] Laboratory analysis of low-level radioxenon samples in support of the International Monitoring System	Dr. DOUYSSET, Guilhem (CEA/DAM/IDF)
14:40	[153] Addition of Active Background Suppression for an International Monitoring System Gamma Detector	Mr. CANTALOUB, Michael (PNNL)
15:00	[143] Low-Background Gamma Spectrometry for the International Monitoring System	Dr. GREENWOOD, Larry (Pacific Northwest National Laboratory)

Special Session: Monitoring Networks: Session 2 Poster Introduction - (15:20-15:30)

- Conveners: Dr. Aalseth, Craig (Pacific Northwest National Laboratory); Prof. Povinec, Pavel (Comenius University, Department of Nuclear Physics)

time	[id] title	presenter
15:20	[196] Special Session: Monitoring Networks Session 2 Poster Introduction	Dr. AALSETH, Craig (Pacific Northwest National Laboratory) Prof. POVINEC, Pavel (Comenius University, Department of Nuclear Physics)
15:22	[169] Development of an underground multidimensional gamma-spectrometer	Dr. BURNETT, Jonathan (Pacific Northwest National Laboratory)
15:24	[148] Low-Background Radioxenon Detector	Dr. FOXE, Michael (Pacific Northwest National Laboratory)

Coffee Break (15:30-16:00)

Metrology and Citizen Initiatives Workshop (16:00-18:00)

- Conveners: Ms. Brandenberger, Jill (Pacific Northwest National Laboratory)

time	[id] title	presenter
16:00	[178] Workshop Overview	Ms. BRANDENBERGER, Jill (Pacific Northwest National Laboratory)
16:05	[179] Introductory Remarks	Dr. HULT, Mikael (EC-JRC-IRMM)
16:25	[139] DoseNet: building scientific literacy through a network of radiation detection devices	Dr. HANKS, Janette (UC Berkeley)
16:45	[180] Our Radioactive Ocean - Citizen Science	BUESSELER, Ken (Woods Hole Oceanographic Institution)
17:25	[181] Panel Discussion	

Friday 30 September 2016

Registration (08:00-09:00)

Quality: Session 1 (09:00-10:00)

 - **Conveners: Dr. BRUGGEMAN, Michel (SCK-CEN); Dr. HINO, Yoshio (NMIJ/AIST)**

time	[id] title	presenter
09:00	[68] SURROGATE POST-DETONATION URBAN DEBRIS (SPUD) STANDARD REFERENCE MATERIAL	Dr. MANN, Jacqueline (National Institute of Standards and Technology)
09:20	[43] Development and characterization of nuclear forensic reference materials for measurement of trace-level actinide elements	ESSEX, Richard (National Institute of Standards and Technology)
09:40	[96] Development of a Low-Level 39Ar Calibration Standard – Analysis by Absolute Gas Counting Measurements Augmented with Simulation	WILLIAMS, Richard (Pacific Northwest National Laboratory)

Quality: Session 1 Poster Introduction - (10:00-10:20)

 - **Conveners: Dr. BRUGGEMAN, Michel (SCK-CEN); Dr. HINO, Yoshio (NMIJ/AIST)**

time	[id] title	presenter
10:00	[197] Quality Session 1 Poster Introduction	Dr. BRUGGEMAN, Michel (SCK-CEN) Dr. HINO, Yoshio (NMIJ/AIST)
10:01	[80] PRODUCTION OF SPIKED VEGETATION SAMPLES CONTAINING GAMMA-EMITTING RADIONUCLIDES TO PARTICIPATE IN PROFICIENCY TESTING PROGRAMS	Ms. DE SOUZA, Poliana (IRD)
10:02	[97] Proficiency testing for measurement quality control of gamma ray spectrometry using brown rice.	Ms. FURUKAWA, Rio (National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology)

Coffee Break (10:20-10:40)

Quality: Session 2 (10:40-12:00)

 - **Conveners: Harms, Arvic (IAEA); Dr. Williams, Richard (Pacific Northwest National Laboratory)**

time	[id] title	presenter
10:40	[159] IAEA proficiency tests for determination of radionuclides in sea water	Dr. HARMS, Arend (IAEA)
11:00	[117] Practical implementation of ISO 11929: 2010	Dr. DE FELICE, Pierino (ENEA)
11:20	[77] Consensus evaluation of radioactivity-in-soil reference materials in the context of an NPL Environmental Radioactivity Proficiency Test Exercise	Dr. DEAN, Julian (NPL)

Quality: Session 2 Poster Introduction - (12:00-12:20)

- **Conveners: Harms, Arvic (IAEA); Dr. Williams, Richard (Pacific Northwest National Laboratory)**

time	[id] title	presenter
12:00	[198] Quality Session 2 Poster Introduction	HARMS, Arvic (IAEA) Dr. WILLIAMS, Richard (pacific northwest national laboratory)
12:01	[42] Calculation of the detection limits by explicit expressions	Mrs. GLAVIC-CINDRO, Denis (Jožef Stefan Institute)
12:02	[84] International Rn-222 in drinking water interlaboratory comparison	Dr. KELLEHER, Kevin (Office of Radiological Protection, EPA)

Lunch (12:20-13:40)

Special Session: Metrology of NORM (13:40-15:00)

- **Conveners: Dr. Hult, Mikael (EC-JRC-IRMM); Prof. Sima, Octavian (Physics Department, University of Bucharest, Romania)**

time	[id] title	presenter
13:40	[172] INVITED TALK: Emerging social, scientific and legislative triggers for the application and development of LLRMT resolving NORM issues	Prof. MARINGER, Franz Josef (BEV - Federal Office for Metrology and Surveillance)
14:00	[183] INVITED TALK: Issues associated with the Metrology of TENORM	SCHWAB, Kristen (Washington State Department of Health Office of Radiation Protection)
14:20	[103] Advancements in NORM metrology - Results and impact of the European joint research project MetroNORM	Prof. MARINGER, Franz Josef (BEV - Federal Office for Metrology and Surveillance)
14:40	[38] REFERENCE MATERIALS PRODUCED FOR A EUROPEAN METROLOGICAL RESEARCH PROJECT FOCUSSING ON MEASUREMENTS OF NORM	Mr. LARIJANI, Cyrus (NPL)

Special Session: Metrology of NORM: Poster Introduction - (15:00-15:20)

- **Conveners: Dr. Hult, Mikael (EC-JRC-IRMM); Prof. Sima, Octavian (Physics Department, University of Bucharest, Romania)**

time	[id] title	presenter
15:00	[199] Special Session: Metrology of NORM Poster Introduction	Dr. HULT, Mikael (EC-JRC-IRMM) Prof. SIMA, Octavian (Physics Department, University of Bucharest, Romania)
15:01	[75] Study of particular problems appearing in NORM samples and recommendations for best practice gamma-ray spectrometry	Prof. MARINGER, Franz Josef (BEV - Federal Office of Metrology and Surveying, Arltgasse 35, A-1160 Vienna, Austria)

15:02	[37] Application of an Artificial Neural Network for evaluation of activity concentration exemption limits in NORM industry	Ms. WIEDNER, Hannah (BEV)
15:04	[81] Analysis and Evaluation for Consumer Goods containing NORM in Korea	Dr. JANG, Mee (Korea Atomic Energy Research Institute)
15:06	[101] A low-energy set-up for gamma-ray spectrometry of NORM tailored to the needs of a secondary smelting facility	Dr. HULT, Mikael (EC-JRC-IRMM)
15:08	[74] Characterisation of the natural radioactivity of the first geothermal installation in Flanders, Belgium	Dr. BRUGGEMAN, Michel (SCK-CEN, Belgium)
15:10	[99] Measurement of radon exhalation rate in NORM used as consumer products	Dr. IWAOKA, Kazuki (Hirosaki University) Dr. HOSODA, Masahiro (Hirosaki University Graduate School of Health Sciences)
15:12	[47] MEASUREMENT OF NORM SAMPLES WITH CeBr3 DETECTORS	Dr. PEYRES, Virginia (CIEMAT)

Closing Ceremony (15:20-16:00)

 - **Conveners: Ms. Brandenberger, Jill (Pacific Northwest National Laboratory); Dr. Hult, Mikael (EC-JRC-IRMM)**

Remove Posters (16:00-17:00)

8.0   Sponsor Advertisements

Appendix A
Book of Abstracts

Contribution ID : **35**   Type : **Oral Presentation**

Coordinated underground measurements of gamma-ray emitting radionuclides for plasma physics research

Tuesday, 27 September 2016 16:10 (0:20)

Content

A coordinated measurement campaign was conducted in four European underground laboratories aiming to assist in analysing the plasma conditions in the KSTAR (Korea Superconducting Tokamak Advanced Research) thermonuclear fusion facility. Forty-eight samples made of $CaF2$, LiF and $YVO4$ (12 samples of each type) and each with a 1-cm2 area were placed inside the KSTAR Tokamak. A special feature of this experiment was that seven individual plasma pulses were studied. This was realised by turning the sample holder inside the Tokamak between each pulse so that only one set (six samples, two of each type) of samples at a time was exposed to the charged particles leaking from the plasma. The eighth set of samples was exposed solely to neutrons. The radionuclides produced by neutron and charged particle activation were measured with HPGe-detectors. Due to the short duration of plasma pulses (between 5 and 40 seconds) and the relatively low power (compared to what is planned for ITER) the activity of activation products of interest was very low and ultra low-level gamma-ray spectrometry was necessary. To be able to measure all 48 samples (plus 3 blank samples) in a reasonable time and to search for possible short-lived radionuclides (half-life of a few days) a coordinated action between several underground laboratories was launched. Four laboratories from the network CELLAR (Collaboration of European low-level underground laboratories) contributed with measurements. Details of the underground measurements are presented together with metrological data on the quality control and calibrations. The activation technique is today the only possible way to monitor charged particles inside Tokamaks. The present work aims to both improve the technique for future use in ITER and to study plasmas produced in existing Tokamaks.

About the Presenter

Mikael Hult is Swedish and Head of the Radionuclide Metrology Sector at the European Commission's Joint Research Centre in Geel (IRMM). He is also the coordinator of the ICRM low-level measurement techniques working group. His PhD (Lund University, Sweden) and postdoc work was about ion beam analysis of GaAs-structures. After working a few years on primary standardisation techniques Dr. Hult was put in charge of the low-level radioactivity group of IRMM and as such leading the work in the 225 m deep underground laboratory HADES. As a consequence of this work he initiated the network CELLAR in 1999 triggered by discussions at the ICRM-LLRMT conference in Mol the same year.

Primary author(s) :   Dr. TZIKA, Faidra (EC-JRC-Geel)

Co-author(s) :   Dr. HULT, Mikael (EC-JRC-Geel); Dr. BANDAC, Iulian (Laboratorio Subterráneo de Canfranc); Dr. DEGERING, Detlev (VKTA – Strahlenschutz, Analytik & Entsorgung Rossendorf); Dr. DE VISMES-OTT, Anne (IRSN/PRP-ENV/STEME/ LMRE, Environnement Radioactivity Measurement Laboratory); Dr. FENYVESI, András (Institute

for Nuclear Research (MTA Atomki) Hungarian Academy of Sciences); Dr. IANNI, Aldo (Laboratorio Subterráneo de Canfranc); Dr. LAUBENSTEIN, Matthias (INFN, Laboratori Nazionali del Gran Sasso); Mr. MARISSENS, Gerd (EC-JRC-Geel); Mr. HEIKO, Stroh (EC-JRC-Geel)

Presenter(s) :   Dr. HULT, Mikael (EC-JRC-Geel)

Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **36**   Type : **Poster**

Development of a dual-HPGe low background gamma-gamma coincidence/anticoincidence spectrometer

Wednesday, 28 September 2016 14:46 (0:02)

Content

The Comprehensive Nuclear-Test-Ban-Treaty (CTBT) verification regime includes a network of radionuclide laboratories. The certified laboratory must meet certain sensitivity requirements for CTBT relevant radionuclides. The Radiation Protection Bureau (RPB) of Health Canada has been running such a certified laboratory (CAL05) since 2005. RPB has recently designed and developed a multi-detector gamma-beta spectroscopy system to improve the sensitivity of measurements and process efficiency for treaty compliance. The spectrometer consists of two HPGe detectors, a PIPS beta gas cell detector (will be installed), plastic cosmic veto detectors and an XIA LLC Digital Gamma Finder (DGF)/Pixie-4 software and card package for list-mode data acquisition. Such design enables a more selective measurement of radioactive xenon (135Xe, 133mXe, 133Xe, 131mXe) released from underground nuclear tests to atmosphere, and a significantly improved resolution and background reduction with beta-gamma coincidence mode. The use of a list-mode data acquisition technique enables each sample be counted once and processed multiple times to get coincidence and anticoincidence spectra for further improved detection limits, which allows an accurate and timely quantification of radionuclides that decay via both singular and cascade gamma emission, greatly enhancing the laboratory effectiveness. The shield of the spectrometer includes four inches very low background lead (Doe Run Lead, <30Bq/Kg), two inches 2% boron in polyethylene neutron layer, one inch ultra-low background inner lead shield (<3Bq/Kg) and a cosmic veto active shielding layer. The spectrometer integral background rate from 40 to 2700 keV is about 0.3 counts per second. Its background characteristics and cosmic veto efficiency are discussed.

A series of measurements were conducted with the spectrometer to determine the intensity and attenuation factors of cosmic-muon. Data were obtained at several sites in two different laboratories, one at surface level and one in an underground location. The results indicate that the overburden in the building at surface level absorbs a large part of cosmic ray protons while attenuating the cosmic-muon intensity by 20-50%. The underground facility has the largest overburden of 39 m water equivalent, where the cosmic-muon intensity is reduced by a factor of 6. The study provides a cosmic-muon intensity measurement and overburden assessment, which are important parameters for analysing the background of an HPGe counting system, or for comparing the background of similar systems.

About the Presenter

Dr. Zhang's research focused on developing and improving gamma, beta and alpha-spectrometry for improved monitoring of environmental radioactivity and investigating radiation exposure to humans from natural and anthropogenic radiation sources.

Primary author(s) :   Dr. ZHANG, Weihua (Radiation Protection Bureau of Health Canada)

Presenter(s) :   Dr. ZHANG, Weihua (Radiation Protection Bureau of Health Canada)

Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **37**   Type : **Poster**

Application of an Artificial Neural Network for evaluation of activity concentration exemption limits in NORM industry

Friday, 30 September 2016 15:02 (0:02)

Content

Naturally occurring radionuclides such as 40K and the decay products of the primordial radionuclides 232Th, 235U and 238U are present in many natural resources. Naturally occurring radioactive materials (NORM) containing these radionuclides are exploited by industrial endeavours and often exceed the exemption limits of the activity concentration for radionuclides of the U and Th series, depending on mineral composition and geological origin. Industrial activities are generating a significant portion of waste and can enhance the potential of exposure of workers and the public. Furthermore, the management and deposition of material above the exemption limit is very costly. The European Metrology Research Project MetroNORM focuses on creating traceable, accurate, and standardised measurement methods, reference materials and systems for (in-situ) application in the concerned industries. The main problem with measuring NORM lies in the variety of densities and compositions of the materials. NORM emits many gamma-rays of different energies that have to be measured and analysed by an expert. Furthermore, the sample activity often barely exceeds the background and long measuring times and expert knowledge for analysing the spectrum are required. One alternative way to approach the problem is the use of artificial neural networks (ANNs). ANNs are mathematical software tools that emulate the way the human brain works. They are trained, tested and validated with sample datasets and capable of "learning by doing". They can generalise the "knowledge" gained by the content of the training set and apply it to new problems. This can be viewed as a new calibration tool where no expert knowledge of gamma-ray spectrometry is needed by the end-user. In this work an ANN was created in the frame of MetroNORM that is able to decide from the input data of a raw gamma-ray spectrum if the activity concentrations in a sample are above or below the exemption limits. To train the network, six NORM reference materials have been analysed and measured. A total number of twelve interference-free lines relevant to the NORM industry were chosen for analysis by the ANN. To widen the applicability of the algorithm, a set of artificial gamma-ray spectra with varying density, activity concentration and material composition has been created using the Monte Carlo codes PENELOPE 2014 and PENNUC (CIEMAT) for training, testing and validation of the ANN. Furthermore, different states of broken equilibrium have been studied for these materials and used as training data. In order to classify the activity content of the input samples five activity categories (on the exemption limit, two near but above and below the exemption limit, far above or below the exemption limit) were chosen. The resulting ANN is a feed forward artificial neural network consisting of one hidden layer containing 31 hidden nodes using a backpropagation algorithm and a logarithmical transfer function to adjust the connection weights. The ANN was able to classify the testing materials (that have not been used as training data) correctly. The results show that the approach is feasible and has great potential for application in the concerned industries.

About the Presenter

The presenter studied physics at the Technical University of Vienna and is now working at the Austrian Federal Office of Metrology and Surveying. She was granted an Early Stage Research Mobility Grant by EURAMET and has researched ANNs at CIEMAT/Spain.

Primary author(s) :   Ms. WIEDNER, Hannah (BEV)

Co-author(s) :   Dr. PEYRÉS, Virginia (CIEMAT); Dr. CRESPO, Teresa (CIEMAT); Dr. MEJUTO, Marcos (CIEMAT); Dr. GARCÍA-TORAÑO, Eduardo (CIEMAT); Dr. MARINGER, Franz Josef (BEV)

Presenter(s) :   Ms. WIEDNER, Hannah (BEV)

Session Classification :   Special Session: Metrology of NORM

Track Classification :   Special Topic: Metrology of NORM

Contribution ID : **38**   Type : **Oral Presentation**

REFERENCE MATERIALS PRODUCED FOR A EUROPEAN METROLOGICAL RESEARCH PROJECT FOCUSSING ON MEASUREMENTS OF NORM

Friday, 30 September 2016 14:40 (0:20)

Content

ABSTRACT

The planet and its atmosphere contains many different NORM radioactive species and all minerals and raw materials contain radionuclides of natural origin. For most human activities, the levels of exposure to these radionuclides are not significantly greater than normal background levels. Material giving rise to these enhanced exposures has become known as naturally occurring radioactive material (NORM). When such materials are being handled or processed, it is clearly necessary to determine the radionuclides present and their activity concentrations. There is a general need for environmental radioactivity solid reference materials to serve as quality control materials to achieve traceability, method validation and instrument calibration. In the context of NORM, the European Metrology Research Programme (EMRP) project IND57 (MetroNORM) addresses some of these issues by investigating present state-of-the-art and suggesting improvements and novel developments for • reference materials and sources, • in situ measurement systems and sampling methods, • standardisation and development of measurement procedures, • improvements of NORM related decay data, and • on-site and in situ testing of the measurement procedures This paper is concerned with MetroNORM work package 1 'Reference Materials and Sources' and will detail the options considered for selecting suitable reference materials to support diverse NORM-industries such as: extraction of rare earths, niobium/tantalum ore processing, TiO_2 pigment production, phosphate processing industries, construction materials, metal processing and smelting, water production, recycling industries and the oil and natural gas industries. We will describe the radiological and chemical characterisation of candidate nuclides and how this information was used to generate a list of 4 reference materials (sand, TiO_2, ionex resin and tuff) for further investigation and characterisation. The characterisation of the chosen materials will detail the measurements made using: • non-destructive techniques including γ-spectrometry and X-ray fluorescence, and • destructive analysis including mass spectrometry and α-spectrometry. The data analysis employed to interpret the results of the characterisation measurements will be detailed, and agreed values for certificated values of these materials will be presented, along with some additional comments about the radioactive equilibrium state of the various uranium and thorium decay series.

About the Presenter

Cyrus Larijani joined NPL in 2011 as a radiochemist for the Radioactivity Measurement Group after graduating with a BSc in Earth sciences and an MSc in Environmental Chemistry from the University of London. Cyrus is currently studying for his Engineering Doctorate at the University of Surrey, which is due to be completed by October 2016. Cyrus currently leads the work on NORM at NPL and is the main point of contact for the EMRP project

MetroNorm. His research interests include NORM, production of radioactive standards and high energy proton-induced fission reactions involving Uranium isotopes.

Primary author(s) :   Mr. LARIJANI, Cyrus (NPL)

Co-author(s) :   Dr. CRESPO, Teresa (CIEMAT); Mr. JEROME, Simon (National Physical Laboratory); Prof. MARINGER, Franz Josef (BEV - Federal Office for Metrology and Surveillance); Dr. LUTTER, Guillaume Lutter (IRMM); Ms. MAZANOVA, Monika (CMI); Dr. DE FELICE, Pierino (ENEA)

Presenter(s) :   Mr. LARIJANI, Cyrus (NPL)

Session Classification :   Special Session: Metrology of NORM

Track Classification :   Special Topic: Metrology of NORM

Contribution ID : **40**
Type : **Oral Presentation**

Leda: a new low level spectrometer using gamma-gamma coincidence

Wednesday, 28 September 2016 14:00 (0:20)

Content

The French Institute of Radioprotection and Nuclear Safety (IRSN) is responsible for performing radiological environment surveillance in France. In this context radioactivity in environment samples (e.g. soils or sediments or biota sampled in the marine or terrestrial environment, or aerosol filters in the atmospheric one) are measured at trace levels in the laboratory of environmental radioactivity measurement by low level gamma ray spectrometry. Metrology developments have been made during the last decades in order to deal with the globally decreasing levels of the anthropogenic radioactivity in the French environment. This paper presents the latest development of a gamma ray detection system based on the use of the emissions of gamma rays in coincidence. This system called Leda consists of 2 HPGe detectors (Castor and Pollux) face to face surrounded by a NaI scintillator (Helene). The acquisition system is a digital electronics working in list mode. It records all events detected by each detector with time and energy information. Thanks to the data analysis code all the following information can be analyzed in one measurement:

1. Sum spectrum of both Ge detectors The efficiency increase leads to decrease uncertainties and detection limits and counting time for all emitters.

2. Anti-coincidence spectrum This spectrum is obtained by summing both spectra obtained by each Ge in anti-coincidence with the other Ge and the NaI. It combines anti-Compton and anti-cosmic features of particular interest for all emitters not affected by coincidence (called "single" emitters):

3. The Compton continuum decrease leads to a better determination of "single" emitters with energy lower than 1460 keV (e.g. Cs-137) in biological matrices containing much K-40, or with energy lower than 477 keV (e.g. I-131) in aerosol filters containing much 7Be.

4. The cosmic ray induced background decrease leads to a better determination of Cs-137 in aerosol filters for instance.

5. Coincidence matrices and spectra (Ge-Ge or Ge-NaI in coincidence) These 4 plots are the most powerful tools for all the coincidence emitters (e.g. Co-60, Cs-134...) due to a dramatically decreased background. Moreover the multiple data (peaks in spectra and fingerprints in matrices) can be accumulated to get a better determination. The choice to use one of these 4 matrices or spectra is made after an in-depth study of the radionuclide decay scheme. It is for instance the Ge-NaI matrix for 60Co or 22Na, and the Ge-Ge spectrum and matrix for Cs-134, Ag-108m and Ag-110m.

Standard sources are used to calibrate the detection system. Calibration factors are also calculated with Monte Carlo MCNP-CP code: for the radionuclides contained in the standard sources in order to validate the model of the simulated system and afterwards for radionuclides not easily available in classical standard source.

This new system is versatile since all gamma emitters can be measured: single emitters in the anti-coincidence mode and coincident emitters in the coincidence mode in the same measurement. Detection limits are improved for all radionuclides with these various detection modes either by increasing the detection efficiency (case 1) or by decreasing the background (cases 2 and 3).

About the Presenter

Hugues Paradis is a PhD student who will defend its thesis at the end of 2016. The paper presents his work on the design of a new gamma-ray spectrometer using gamma-gamma coincidence. He has also developped and validated the method by using an anti-Compton system already used in the laboratory.

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Session Classification : Radiometrics

Track Classification : Radiometrics

Contribution ID : **42**   Type : **Poster**

Calculation of the detection limits by explicit expressions

Friday, 30 September 2016 12:00 (0:02)

Content

With the detection limit we express the smallest true value of the measurand, which can be detected with a predefined probability. It is calculated by [1]

$y\# = y^* + k_{1-\beta} \cdot u(y\#)$, (1)

where $k_{1-\beta}$ denotes the quantile of the standardized normal distribution corresponding to the predefined probability β and y^* the decision threshold, i.e the value of the measurand for which when exceeded the probability, that the true value of the measurand is zero, is less than a predefined probability α

$y^* = k_{1-\alpha} \cdot u(0)$. (2)

Here $u(0)$ denotes the null-measurement uncertainty, i.e. the uncertainty of the observed value of the measurand equal to zero. The equation (1) is an implicit equation, which can be, in general, solved by iteration [1].

In radiation measurements the measuring function is [1]

$y = w \cdot nn$, (3)

where nn is the net indication and w denotes the conversion factor converting the net indication into the observed value of the measurand. Since

$u(y)^2 = w^2 \cdot u(nn)^2 + nn^2 \cdot u(w)^2$, (4)

it follows from equation (1)

$nn\# = nn^* + k_{1-\beta}' \cdot u(nn\#)$, (5)

where $nn\#$ and nn^* are the indications corresponding to the detection limit and the decision threshold and $k_{1-\beta}'$ denotes

$k_{1-\beta}'^2 = k_{1-\beta}^2 \cdot [1 + u(w)^2/w^2 \cdot nn\#^2/u(nn\#)^2]$. (6)

This quantile corresponds to the probability β' of the indication, which takes into account the uncertainty of the conversion factor and in Eq. (5) replaces the quantile corresponding to the predefined probability β. It is obvious from the Eq. (6) that the quantile in the net indication is proportional to the quantile in the measurand and that the factor of proportionality is given by the relative uncertainties of the conversion factor and the indication corresponding to the detection limit.

It is clear that also Eq. (6) presents an implicit equation for $k_{1-\beta}'$, since the relative uncertainty $nn\#/u(nn\#)$ depends on it. However, in case when the uncertainty of the background dominates the uncertainty budget of the net indication, the uncertainty of the net indication does not depend on the value of the net indication, i.e. $u(nn=0) = u(nn\#)$. Then Eq. (6) simplifies to

$k_{1-\beta}'^2 = k_{1-\beta}^2 \cdot [1 + u(w)^2/w^2 \cdot (k_{1-\alpha} + k_{1-\beta}')^2]$, (7)

from where

$k_{1-\beta}' = [k_{1-\beta}^2 \cdot k_{1-\alpha} \cdot u(w)^2/w^2 + k_{1-\beta} \cdot \text{sqrt}(1+(k_{1-\alpha}^2 - k_{1-\beta}^2)u(w)^2/w^2)] / (1 - k_{1-\beta}^2 \cdot u(w)^2/w^2)$

(8)

follows. Then, according to Eqs. (3) and (5), the detection limit is

$y\# = w \cdot u(nn=0) \cdot (k_{1-\alpha} + k_{1-\beta}')$. (9)

Eq. (9) shows that in the case when the uncertainty of the background dominates in the uncertainty budget of the net indication, the decision threshold could be expressed in a closed form. In the contribution numerical examples of calculation of decision threshold for various relative uncertainties of the indication will be presented. It will be demonstrated that the described method is useful when the uncertainty of the conversion factor is large,

because then the successive approximations yielded by the iteration process slowly converge. When the series of successive approximations does not converge, i.e. when $u(w)/w > 1/k_{1-\beta}$, also Eq. (8) yields a negative value for $k_{1-\beta}$', which can't be interpreted statistically. Reference: [1] ISO 11929(2010): Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for measurements of ionizing radiation – Fundamentals and application, ISO, 2010.

About the Presenter

Matjaz Korun:
Since 35 years I am engaged in gamma-ray spectrometric measurements of environmental samples. During this time I developed gamma-ray spectrometers with the aim of decreasing the detection limits. I developed also methods for efficiency calculations, coincidence summing corrections, characterization of backgrounds and calculations of decision thresholds and detection limits. In the field of quality assurance I was active in the areas where the metrological approach is relevant: traceability of results, calculation of characteristic limits, assessment of uncertainties, assessment of correlation coefficients and assessment of reliability of peak analysis results. In last years the focus of my research is on the reliability of measurement outcomes near the decision threshold. In this field I have published 15 articles in last four years. My motivation for this work is to decrease the systematic influences on the doses, assessed from gamma-ray spectrometric results of environmental samples, where the outcomes near the decision threshold are abundant.

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Session Classification : Quality

Track Classification : Quality

Contribution ID : **43**   Type : **Oral Presentation**

Development and characterization of nuclear forensic reference materials for measurement of trace-level actinide elements

Friday, 30 September 2016 09:20 (0:20)

Content

Since 2009, the Department of Homeland Security National Technical Nuclear Forensics Center (NTNFC) has been sponsoring the development of reference materials to enhance the accuracy, precision, and traceability of nuclear forensic analytical capabilities. This work has been a collaborative effort between NTNFC, the Federal Bureau of Investigation, the National Institute of Standards and Technology, the Department of Energy, DOE National Laboratories, and international partners. The goal of this program is to provide certified analytical standards that can improve the resolution of current measurement capabilities and/or provide a level of quality control necessary to demonstrate the reliability of analytical results and meet evidentiary requirements for a court of law. As such, these new reference materials should be homogeneous and be provided in an appropriate form, quantity, and purity to meet analytical needs. Furthermore, characterized attributes must be reproducible, have reasonably low measurement uncertainties, and be traceable to national and international standards. To date, most of the nuclear forensic reference material projects have focused on challenging measurements of amount fraction and isotope amount ratios of actinide elements, including transuranic elements, that occur as trace constituents («100 mg / kg) in other materials. Meeting all of these requirement for low-level actinide analytical standards is a complex task and each reference material project presents a unique set of challenges. Despite the complexity of the task, this collaborative project has successfully produced and certified nuclear forensic reference material and is making significant progress toward the development, characterization, and certification of additional reference material that will improve and expand measurement capabilities for trace quantities of actinide elements.

Individual reference material projects are at various stages of completion from initial planning to currently available CRMs and fall into two main categories: enriched isotope tracers for low-level isotope dilution mass spectrometry (IDMS) measurements and matrix reference material for method development, validation, and quality control. New IDMS tracer reference materials that have been produced include solutions of Am-243 (isotope amount fraction of 0.9999 at 0.4 µmol / kg) and Th-229 (isotope amount fraction of 0.99987 at 0.115 µmol / kg). IDMS tracers that are in the planning or early production stages include Np-237 (target attributes: isotope amount fraction of 0.8 to 0.9 at 0.04 µmol / kg), Pa-231 (target attributes: isotope amount fraction >0.999 at 0.01 µmol / kg) and U-233 (Target attributes: isotope amount fraction > 0.999 at 4.3 µmol / unit). Matrix reference materials include U reference materials for radiochonometric measurements (certified Th-230 / U-234 model purification ages), trace U isotopes in U materials (U-232 isotope amount fractions ranging from 460×10^{-12} to 8.2×10^{-12} and isotope amount fractions for 233U ranging from 1.5×10^{-6} to 0.2×10^{-6}), Trace actinide elements in a U oxide matrix (amount fractions at mg / kg levels or lower for Th, Pu, Am, Np) and Trace actinide elements in a Pu oxide matrix (amount fractions at mg / kg levels for U, Np, Am).

About the Presenter

Richard Essex has be working on the production, characterization, and certification and nuclear and nuclear forensic reference materials for the last 15 years. This includes his current position at the National Institute of Standards and Technology and his previous position at the Department of Energy's New Brunswick Laboratory. His academic background is in geology and isotope geochemistry with a BS from the University of Rhode Island, an MS from Virginia Tech, and a PhD from Brown University.

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Session Classification :   Quality

Track Classification :   Quality

Contribution ID : **44**   Type : **Oral Presentation**

Detection and assessment of specific natural organic compounds as carriers for radionuclides (e.g., I, Pu) in soil and water environments at ambient concentrations

Tuesday, 27 September 2016 10:40 (0:20)

Content

Radionuclides that reach the environment from natural or anthropogenic sources are equilibrating over time with different phases through sorption and precipitation reactions onto inorganic and organic phases, e.g., specific macromolecular natural organic matter (NOM) compounds. The presence of NOM in contaminated soils complicates conventional remediation techniques that often add base to either increase the cation exchange capacity of soils or to promote direct precipitation of the radionuclide in the waste stream. This addition then has the consequence that both isotopes become more, rather than less, mobile in organic matter-enriched sediment. In order to assess how environmental factors affecting the distribution and transport of radioiodine and plutonium that are entering soils and water environments, sensitive techniques are required not only for the detection and identification, at ambient concentrations, of isotopic ratios and radionuclide concentration and speciation, but also for potential trace organic compounds that are chemically binding these compounds. This presentation will focus on Iodine (e.g., 129I) and Plutonium (e.g., 239,240Pu) as examples where specific organic compounds affect speciation and transport. Iodine, which has multiple radioisotopes, occurs in multiple oxidation states in aquatic systems in the form of organic species ((organo-I, where I is covalently bound by aromatic moieties) and inorganic species (iodide (I-) and iodate (IO3-). This fact leads to complex biogeochemical cycling of iodine and its long-lived isotope, 129I, a major by-product of nuclear fission. Plutonium (in oxidation state IV) has been demonstrated to be strongly chelated by hydroxamate siderophores in the laboratory and the field. Approaches and techniques that were successful in the study of I and Pu speciation and interaction with specific NOM compounds from different field studies (e.g., Fukushima, Japan, Savannah River Site, South Carolina, Rocky Flats in Colorado, and Hanford, Washington) using radiochemical and organic chemical methods will be discussed. These methods are a significant improvement over existing techniques, e.g., simultaneous detection and quantification of isotope ratios and their speciation via radiochemical and organic chemical methods at ltheir low concentrations, resulting in easier detection at lower concentrations.

About the Presenter

Peter H. Santschi, Regents Professor of Texas A&M University and Professor of Marine Sciences (TAMUG) and Oceanography (TAMU), elected Fellow of the American Geophysical Union (2014), recipient of the Distinguished Achievement Award in Graduate Student Mentoring (2013), and Research (2004) from Texas A&M's Association of Former Students. He is an innovative scientist. Santschi is internationally recognized and is frequently an invited speaker and conference session chair, NSF and DOE review panelist, Associate Editor for Marine Chemistry, and more. A defining feature of his work is his special ability to integrate knowledge from many different disciplines. His research interests in

biogeochemistry and environmental science include: mobility and speciation of radioactive and toxic trace contaminants, including radionuclides, trace metals, and natural or persistent organic compounds, in surface waters, sediments and ground water; sediment-water and particle-water interactions, with emphasis on colloids and biomacromolecules; natural organic matter geochemistry, including exopolymeric and humic substances; and metal-organic matter binding and other interactions. URL: http://loer.tamug.edu/people/Santschi/index.html.

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Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **45**   Type : **Oral Presentation**

Study about the radionuclides implanted on glass surfaces for the estimation of retrospective indoor radon concentrations

Monday, 26 September 2016 11:20 (0:20)

Content

Retrospective dosimetry due to indoor radon exposure requires measurement methods allowing the determination of mean radon concentrations in the past. One of the such methods is based on the direct measurement of 210Po implanted on the surface of objects, whose activity concentration (Bq/m2), is directly related to the cumulative exposure due to the concentration of 222Rn (Bq/m3) for long time. These determinations are possible taking into consideration the equilibrium between 210Po (T1/2 = 138.378 days) and its parent 210Pb (T1/2 = 22.3 years), being both radionuclides from the 222Rn progeny. In a previous work [1] about the determination of the conversion factor (ratio between the concentration of 210Po in objects and the retrospective 222Rn concentration in air), corresponding equilibria between descendants were assumed. In this work, an experimental study about the equilibrium 210Pb - 210Po in glasses, which were previously exposed to considerable radon concentrations, has been performed. Two scenarios were studied: a place without, and another place with, continuous cumulative 222Rn concentration. In the first site, a mirror was exposed for a short time (4 months) to an environment with very high radon concentration (about 30 kBq/m3), whereas in the second case, a similar mirror is being exposed since July 2011 (and now it continues) in a room with moderate radon concentration (about 200 Bq/m3). Both mirrors are being measured from time to time by alpha-particle spectrometry in order to determine the 210Po concentration in the surface. Experimental results are being compared with those reached by theoretical calculations from the activity evolution equations. The results reached in the measurement of the first mirror, short-time exposed to a great radon concentration, can be only explained considering an extra quantity (not only that due to recoil implantation) of 210Po in the mirror surface. This extra 210Po concentration on the surface glass should appear by additional implementation of 210Bi and 210Po, produced by electrostatic attraction process. This effect is only predominant when the mirror is exposed in an environment composed by a large number of nuclides. In the case of the mirror submitted to a moderate long-time radon concentration, studies are more tedious due to the low-level concentration found in the glass surface. Preliminary results seem to be in agreement with the theoretical predictions expected for these conditions. In our case, five years is the time estimated to reach values above the limit of detection of the experimental device used. In this time, however, the incidence of extra 210Po added by electrostatic effects is lowered to a quantity less than 10%. Anyway, the assignment of correct values for the conversion factor is completely necessary to adequately estimate retrospective radon dose. Only in this way, any correlations between the effects caused by indoor radon concentrations to the human health should be accurately assessed. [1] Martín Sánchez, A., de la Torre Pérez, J., Ruano Sánchez, A.B. Experimental studies about the ratio between 210Po deposited on surfaces and retrospective indoor 222Rn concentrations. Radiat. Prot. Dosim. 160, 206-209 (2014).

About the Presenter

Prof. Dr. Alejandro Martín Sánchez is a teacher at the Department of Physics in the University of Extremadura (Spain). His studies were performed at the Universities of Madrid and Extremadura (Spain), although his formation was completed in several international institutions (The University of Calgary, CERN, Lund Institute of Technology, Universitá degli study di Parma, Turku Politechnique, and several Spanish universities). He has an experience of more than 35 years working with radioactivity and radionuclides. His studies have been devoted to the characteristics of actinides, alpha-particle spectrometry, nuclear structure, or environmental radioactivity. In the last time he has been working with indoor Radon measurements. He has more than 120 research papers published in the journals with the greatest impact factor. He is co-titular of 2 patents. He has participated in about 40 research and development projects, being in more than 20 the principal researcher. He has presented more than 170 communications to specialized scientific meetings.

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Session Classification :   Radioactive Noble Gases

Track Classification :   Radioactive Noble Gases

Contribution ID : **46**   Type : **Poster**

When the mean value does not mean what is really happening: The case of indoor radon concentration measured with track detectors in working places

Monday, 26 September 2016 12:08 (0:02)

Content

The problematic involved with the existence of great values for the indoor radon concentration is regulated by imposing some limits in each country as the values considered as safety levels to preserve human health. In general, large surveys (with a great quantity of samples) for indoor radon concentrations in dwellings are measured exposing passive detectors, such as track detectors, for a given time (for example, three months). The annual average concentration is then estimated taking into consideration the mean value obtained for the exposure time. This value so obtained is then compared with the limits given by the corresponding health authority and, if necessary, some mitigation actions are required to diminish the dose to the affected people. Considering that a typical person could spend during his journey a third part on one day in the working place, measurements of indoor radon concentrations are also necessary. Studies have been performed in this type of sites [1]. In this way, when large surveys are planned to study a great number of samples of population, track detectors are also usually used for the determination of indoor radon concentrations. But when the measurements are performed in working places, other considerations must be taken into account. The problem arises in some working places showing radon concentrations with values above the safety limits. In these cases mitigation actions should be applied. However, studying some of these working places with more detail using continuous radon monitor detectors and determining the hourly concentration, great variations have been found. In these cases only the mean values measured into the time of the normal journey must be considered, because this is really the time spent by the people inside the working dependences. Great differences between both values for concentration have been found in some cases. In order to correctly estimate the real dose received by workers, if the mean value obtained with track detectors is above the safety limits then, studies taking into consideration only the time affecting the real stay of the persons there must be considered. The radon concentration should be monitored with the greatest detail in this case. Passive (and then averaged) track detectors should be avoided or only considered as primary indicators. But the great problem is then the (some orders of magnitude) difference in the price of continuous radon monitor versus track detectors. In a study performed to mitigate radon effects in working places, several examples were found in which ventilation was an adequate action. The average obtained measuring with track detectors indicated high values for the estimated dose received by workers. However, only considering really the time spent by the persons in their working place, as measured with a radon continuous monitor, the estimated dosed were not so high. [1] Martín Sánchez, A., de la Torre Pérez, J., Ruano Sánchez, A.B., Naranjo Correa, F.L. Radon in working places in Extremadura (Spain). J. Environ. Radioact. 107, 86-91 (2012).

About the Presenter

Prof. Dr. Alejandro Martín Sánchez is a teacher at the Department of Physics in the University of Extremadura (Spain). His studies were performed at the Universities of Madrid

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Session Classification :   Radioactive Noble Gases

Track Classification :   Radioactive Noble Gases

Contribution ID : **47**   Type : **Poster**

MEASUREMENT OF NORM SAMPLES WITH CeBr3 DETECTORS

Friday, 30 September 2016 15:12 (0:02)

Content

This paper discusses the use of CeBr3 detector for the analysis of NORM samples. These detectors have a number of characteristics that make them suitable to field measurements: they can work at ambient temperatures, have better energy resolution than NaI(Tl) detectors for energies over 100 keV and do not present the radioactive contamination typical of the lanthanum halides detectors that contain a small fraction (0.09 %) of 138La, a radioactive isotope of La.

To our knowledge, CeBr3 detectors have never been used in the measurement of NORM. This paper describes its use in the frame of the European Metrology Program, MetroNORM (Metrology for processing materials with high natural radioactivity). All reported measurements have been carried out at the laboratory, as a preliminary step for later "in-situ" implementation. The experimental setup was composed by a 7.5 x 7.5 cm (3"x3") detector together with the associated electronics and a 5 cm thick cylindrical lead shield. The sources and materials analyzed were the following:

• Ionex resin with activity concentration levels of 235/238U above the exemption limit. This material does not contain 226Ra + daughters nor 232Th + daughters. Sample weight was approximately 5 g in a sealed polypropylene container.

• Titanium dioxide containing 226Ra + daughters, 210Pb, 228Ra + daughters and 228Th + daughters in activity concentration levels well above the exemption limits. It was measured using a similar container.

• Tuff containing a large mixture of isotopes (U, Ra and Pb) below the exemption limit.

Previously to these measurements, the detector was fully characterized in efficiency terms by a MonteCarlo simulation model using the code PENELOPE/PENNUC. The model was validated with a large number of reference sources (point, extended and liquid) whose activities were determined by absolute and relative methods.

Results of the measurements are compared to those made at the same laboratory using a conventional HpGe gamma-ray spectrometer system. Spectra from both measurement systems are presented and recommendations about the convenience of using these detectors instead of semiconductor models are issued for each kind of material.

About the Presenter

Dr. Virginia Peyres, physicist, responsible for γ measurements in the Radionuclide Metrology Laboratory of CIEMAT, with more than 10-year experience on measurements with semiconductor detectors and Monte Carlo modelling and 10 years of previous experience in nuclear safety.

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Session Classification : Special Session: Metrology of NORM

Track Classification : Special Topic: Metrology of NORM

Contribution ID : **48**   Type : **Oral Presentation**

COMPACT RADIOACTIVE AEROSOL PARTICULATE MONITORING DEVICE FOR EARLY WARNING NETWORKS

Thursday, 29 September 2016 11:40 (0:20)

Content

In a radiological emergency, early and reliable knowledge of radioactivity concentrations in the air, the assessment of contamination levels in the environment and the dose rate levels in urban areas are of key importance for organizing of efficient countermeasures for protection of the general public from the dangers arising from direct external radiation and from intake of radioactivity by ingestion or inhalation of contaminated food or air. Therefore in 2014, a 3-year EMRP joint research project Metrology for radiological early warning networks in Europe (MetroERM) has been launched, with the aim to improve, optimize and harmonize the metrological foundation of measurements of ambient dose equivalent rate, radioactivity concentrations in air and ground contamination levels in real-time.

The aim of this JRP European metrology is to improve the capacity of the early warning networks also by the development of new methods and systems for rapid radioactive air concentration measurements, to efficiently supplement global early warning data with accurate information on airborne radionuclide content. With the development of new modular air sampling systems which can be easily transported to locations for the detection of airborne radioactive particulate the information content provided by early warning networks in real time will be considerably increased.

At JSI a novel aerosol sampling device was developed which incorporates a centrally oriented 1 inch CeBr3 scintillation detector, with ~4% FWHM energy resolution at 662 keV, within a concertinaed filter assembly and an improved air pump with stable flow rates up to 200 m3/h which enables low level airborne radioactivity detection. The sensitivity is additionally boosted by careful scintillator choice which has far better energy resolution compared to alkali halides and far lower intrinsic radioactivity than LaBr3. A fully digital signal processing unit was developed in-house, with a 10 bit MCA, which is more than sufficient to achieve the detector energy resolution limits. The temperature compensation is handled on the software side by a microcontroller-based system connected to a digital thermometer that is in good thermal contact with the detector. The same microcontroller unit is used to handle the user interface, via a 5 inch color touch screen and handles all inputs/outputs (I/O), including 3G network communications. The system provides continuously sensitive on-line airborne radioactive particulate monitoring for field station use. Advantages of the system are:

- a compact radioactive aerosol particulate monitoring device with high flow rate incorporated in a heavy duty portable case which is easily transportable to different measurement locations;

- prompt and continuous online detection and 3G networking to enable data relay to a centralized system from remote field stations for evaluation of gamma emitting radionuclides in spectra;

- remote control of the unit settings and functions;

- increased frequency of data transmission during a nuclear emergency enabling remote analysis of plume deposition.

The compact radioactive aerosol particulate monitoring device for early warning networks and first measurements will be presented and discussed.

About the Presenter

Denis Glavič-Cindro works at Jožef Stefan Istitute in the field of radionuclide metrology and measurements since 1994. She is mostly engaged in high resolution gamma ray spectrometry and since 1999 she regularly and active participates at ICRM and ICRM LLRMT conferences with posters or oral presentations. Beside this her main fields of activities are quality assurance, maintaining quality system in the accredited laboratories dealing with radioactivity measurements at Department F-2 at Jožef Stefan Institute, evaluation and participation in comparison measurements...

She is representative of Jožef Stefan Institute at International Committee for Radionuclide Metrology and contact person at Technical Committee for Ionising radiation (TC-IR) at EURAMET, both since 2011.

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Session Classification : Special Session: Monitoring Networks

Track Classification : Special Topic: Monitoring Networks

Contribution ID : **49**   Type : **Poster**

Natural radon reduction rate of the Community Groundwater System in South Korea

Monday, 26 September 2016 12:10 (0:02)

Content

There is about 8,000 community groundwater systems (CGS) used in South Korea. CGS is used for domestic water where regional water supply system is not available. Among them, it is reported that about 28.8 percent of CGS showed radon activity greater than 100 Bq/L recommended by WHO. The transport procedure of groundwater to each house is that groundwater from a well using a submersible pump is pumped to a water storage tank of about 10 to 60 m3. The groundwater in a storage tank is supplied to each house by gravity. During this process, radon concentration will decrease by natural radon aeration, radon decay and stagnation. To estimate average radon reduction rate at storage tank of CGS, fourteen CGS with above 100 Bq/L were chosen. The average radon reduction rate at storage tanks was 31.3%. Radon reduction rate at a storage tank would be vary with time due to pumping rate and variation in the radon level at each pumping time. To see seasonal variation of radon reduction rate at storage tank a CGW having radon activity above 100 Bq/L was selected and radon levels at well head and storage tank were measured four times. The radon level in well head varied from 780.6 Bq/L to 1,214.2 Bq/L, and radon reduction rate at storage tank varied from 23.0 to 56.5% (average 44.1%). To see hourly variation of radon reduction rate at storage tank five times of radon level measurement were made at well head and storage tank at the same well. The radon level in well head varied from 696.3 Bq/L to 1,056.2 Bq/L, and radon reduction rate at storage tank was from 27.1 to 56.5% (average 42.5%), which is similar to seasonal radon reduction rate at storage tank. When applying the average radon reduction rate of 31.3% at storage tank, the percentage of exceeding rate of 100 Bq/L in 8,000 CGS would be decrease from 28.8% to 18.0%, although the natural radon reduction rate at the storage tank of every CGS would vary with pumping rate, radon level at the time of pumping, and the capacity of storage tank.

About the Presenter

Dr Byong-Wook Cho is working for KIGAM (Korea Institute of Geoscience and Mineral Resources), especially for groundwater resources and radionuclides in groundwater.

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Session Classification :   Radioactive Noble Gases

Track Classification :   Radioactive Noble Gases

Contribution ID : **50**   Type : **Oral Presentation**

DETERMINATION OF LOW LEVEL NP-237 BY VARIOUS TECHNIQUES

Thursday, 29 September 2016 09:40 (0:20)

Content

Np-237, a long-lived (t1/2 = 2.14 E+06 y) alpha emitting radionuclide, is present in the environment primarily as a result of atmospheric weapons testing and discharges from nuclear fuel reprocessing facilities. Np-237 from the decay scheme of Am-241 on the other hand presents only a small portion of the total neptunium in the environment. The aim of this study was to determine the activity of Np-237 in environmental samples by a) a direct gamma-ray spectrometry, b) an alpha-particle spectrometry and c) a radiochemical neutron activation analysis using pre-separated samples. A direct gamma ray spectrometry via Pa-233 daughter is a useful method for determination of neptunium activities higher than 1.5 Bq kg-1. Its detection depends on amount of the sample and an appropriate measuring time. For low level activities of neptunium alpha-particle spectrometry and radiochemical neutron analysis were applied. For both techniques, the samples were ashed, decomposed by a Li Borates fusion and finally radionuclides were coprecipitated with iron hydroxide and the addition of ammonia solution to pH 8. When Np-237 is determined by an alpha-particle spectrometry, samples require extensive chemical separation prior to counting to remove peak interferences from other alpha emitters with similar energies such as U-234, Pa-231 and Th-230. In this work we compared separation procedures by using ion exchange chromatography and extraction chromatography. The alpha spectra obtained after extraction chromatography, however, showed presence of thorium impurities in the neptunium fraction independently of the volume of acids used for washing the resins. The recovery of radiochemical procedure was checked by addition of gamma emitter Np-239, which was prepared by irradiation of μg quantities of uranium solution in our TRIGA reactor. Low level of neptunium was also determined by radiochemical neutron activation analysis. Neptunium fraction was firstly separated from the bulk sample and then irradiated. When Np-237 is irradiated in a reactor the following capture reaction is induced: 237Np(n,γ)238Np. Np-238 is formed by neutron capture with an exceptionally large thermal cross section of 170 barns and resonance integral of 600 barns, possesses a favourable half-life (t1/2 = 2.2 days) and gamma energies at 984.4, 1026 and 1028.5 keV. In the case of a very low activity of the sample additional purification had to be done before γ-ray measurement. The methods used were applied to IAEA soil and sediment reference materials (IAEA 135, IAEA 300, IAEA 326, IAEA 327, IAEA soil 6, IAEA 368), Moss soil IAEA 447, Seaweed NIST SRM 4359 sample and two sediment samples, one from the Cumbrian Coastline, the other from the river Ribble. Results obtained showed good agreement with scarce literature data on activities of Np-237 in environmental samples.

About the Presenter

Prof. Ljudmila Benedik works as a senior research associate at the Department of Environmental Sciences at Jožef Stefan Institute She obtained her PhD from University of Ljubljana in 1994. Her scientific research work was mainly devoted to research in the field of determination of trace elements by neutron activation analysis as well as determination of natural and man-made radionuclides using alpha-particle, beta and gamma-ray spectrometry

and liquid scintillation technique. During 2003 to 2008 she has been working at Institute for Reference Materials and Measurements of the Joint Research Centre of the European Commission (EC JRC IRMM) where she was involved, amongst over, in the projects connected to nuclear safeguard, radionuclide metrology and metrology in chemistry. She published over 60 publications in international peer reviewed scientific journals. She was leading or participating in several national and international project and have experiences in organizing the workshops and conferences. In last years she has supervised several undergraduate and PhD students.

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Session Classification :   Radiochemical Techniques

Track Classification :   Radiochemical Techniques

Contribution ID : **52**   Type : **Oral Presentation**

Laboratory analysis of low-level radioxenon samples in support of the International Monitoring System

Thursday, 29 September 2016 14:20 (0:20)

Content

The radionuclide component of the International Monitoring System (IMS) is based on a worldwide network of 80 radionuclide monitoring stations. In support of the Comprehensive Nuclear Test Ban Treaty (CTBT) verification regime, these stations are designed to perform continuous monitoring of atmospheric radioactivity (for both aerosols and noble gases). The IMS is supplemented by group of 16 certified laboratories, in charge of network quality control and in-depth re-analysis of anomalous samples. Measurements of relevant radioxenon mixtures (133-Xe, 133m-Xe, 131m-Xe, 135-Xe) in laboratory are hampered by i) radioactive decay during sample transportation, ii) low initial activity of the samples (1-100 mBq range), iii) low (gamma/X) emission energy of xenon isotopes and iv) gaseous state of the samples. The French laboratory (RL08) at CEA has set up a complete system designed to perform these specific analyses. As samples are not measurable as received, the first step consists in transferring the content of the stainless steel 0.5 l archive bottle into an optimized 13 cm3 double-sided measurement cell fitted with carbon epoxy windows. Cryogenic separation is used to remove the carrier gas (He or N2) from Xenon so as to maintain the cell internal pressure in an acceptable range. The Gamma3 spectrometry facility [1] is used to perform activity measurements. This system is fitted with state-of-the-art passive and active shielding. The background level achieved with this configuration is found to be among the lowest for a ground-level facility (integral count rate: 2x2.1 cpm, range [20-1000 keV]). Fully digital electronics and listmode data acquisition are implemented so as the three high efficiency Canberra BEGe5030P gamma spectrometers composing the Gamma3 system can operate either in single, additive or (anti)coincidence mode. For radioxenon analysis, the measurement cell is inserted in between two face-to-face gamma spectrometers making a virtual very high efficiency single spectrometer (full-energy peak efficiency > 50% over [20-150 keV] energy range). Finally, Gas-Phase Chromatography (GPC) on stable Xe is used to assess the gas transfer yield and the air equivalent volume as sampled by the on-field station. Taking benefit of the combined high detection efficiency and the very low background of the system, sub-mBq detection limits are achievable within three days measurement time. Except for the very short-lived Xe-135, this extreme sensitivity is not only able to encompass radioactive decay during transportation from remote locations to the laboratory (<10 d) but also in some cases too enhance significantly the station detection capabilities.

[1] An introduction to γ3 a new versatile ultralow background gamma spectrometer. Background description and analysis. A. Cagniant et al, Appl. Radiat. Isot. 87 (2014) 48–52

About the Presenter

Dr. Guilhem DOUYSSET is currently heading the Low-Level Radioactivity Laboratory at CEA/IDF and the french CTBT certified laboratory (also known as FRL08).

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Session Classification : Special Session: Monitoring Networks

Track Classification : Special Topic: Monitoring Networks

Contribution ID : **54**   Type : **Poster**

Monte Carlo optimization of shielding for novel industrial free-release measurement facility

Tuesday, 27 September 2016 12:00 (0:02)

Content

A novel industrial radionuclide-specific free-release measurement facility (FRMF) is being designed, constructed and tested within the scope of a 3-years joint research project "Metrology for Decommissioning Nuclear Facilities" (MetroDecom). The facility is modular and reusable, allows its site-specific optimization including installation of multi-detector modular arrays matching end-user needs, and provides high throughput using a flow-through configuration without movable doors. High sensitivity of the FRMF is realized by gamma-spectrometric High-Purity Germanium (HPGe) detectors installed inside a construction from unique bricks made of concrete with low mass activity of natural radionuclides (uranium and thorium decay series and potassium-40). The aim of the construction is to minimize the radiation background inside the FRMF that originates outside – primarily in the material of walls and floor of the hall where the FRMF is located, allowing to significantly decrease the minimum detectable activities of materials inspected by the FRMF. The presented paper describes the optimization of the design of this concrete shielding by means of Monte Carlo (MC) simulations. The optimization was performed for a monoenergetic source of 1461 keV photons (emitted by K-40) originating inside the floor within 12 m from the FRMF vertical axis. The scored quantity was the fluence of 1461 keV photons at the position of the HPGe detectors. Study focused on the thickness, width and length of FRMF concrete walls and floor, including the floor below conveyer belts and side-walls protecting against radiation that could come inside the FRMF through its open entrances. As the weight of the shielding may easily reach up to 100 tons, the goal was to suggest one or several shielding configurations with the balance between the shielding weight and the decrease of natural background. In addition, the shielding configuration was considered appropriate, if the fluence rate of 1461 keV photons inside the FRMF originated in the floor, per Becquerel, varied at the level of the fluence rate of 1461 keV photons originated in the concrete shielding. To assess this condition, the mass activity of K-40 in the floor was set to a quite high value of 500 Bq/kg while the mass activity of the FRMF shielding was expected to be 6 Bq/kg as determined by a gamma-spectrometric measurement. As resulted from MC simulations, this K-40 mass activity in concrete results in the full-energy peak and total count rate of about 1.3 counts/min and 5.8 counts/min per one HPGe detector IDM-200-V$^{\text{TM}}$ (ORTEC), respectively. The final configuration of the FRMF concrete shielding was selected from suggested configurations based on the complexity of the technical solution and shielding weight. The simulated relative decrease of the 1461 keV full-energy peak count rate will be compared with the one measured at the experimental site once the industrial FRMF is constructed and put into operation in late spring 2016.

About the Presenter

Jaroslav Solc is a metrologist at the Czech Metrology Institute working at the Department of Fundamental Metrology of ionizing radiation. He has long experience with Monte Carlo simulations in the code MCNP. He participates in international scientific projects, primarily

in European projects on ionizing radiation metrology EMRP and EMPIR focused on industry, environment and health.

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Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **57**   Type : **Poster**

The Dortmund Low Background Facility

Wednesday, 28 September 2016 14:50 (0:02)

Content

The Dortmund Low Background Facility (DLB) is a high-purity germanium gamma-ray spectrometry laboratory situated above ground, that reaches sensitivities well below 1 Bq/kg. In contrast to most other low-background screening facilities the DLB is not located in a (deep) underground laboratory, but above ground on the campus of the University of Dortmund. This gives the possibility for easy and quick access to the facility for maintenance and inducing new samples. It was set up initially to support the neutrinoless double beta-decay experiment COBRA at the LNGS, Italy.

An outer shielding is constructed artificially, using about 400 t of concrete and iron, which adds up to an overburden of 10 mwe. This is sufficient to shield the hadronic component of cosmic-rays and reduces the remaining muonic component by a factor of two. For shielding against the ambient environmental radiation (such as thorium and uranium from the surrounding constructions and the radon content in the air of the laboratory) a multi-layer inner shielding is build. It is designed especially for the application above ground, thus the neutron absorber is placed inside the lead layers of the shielding, suppressing the neutron flux at the position of the germanium detector considerably. Although the flux of cosmic muons is already reduced by the outer shielding, the remaining muons make an active muon veto necessary. The muon veto is made of thin plastic scintillators and photomultiplier tubes. The scintillators are rather thin, which results in an insufficient signal discrimination with just one scintillator. A muon detection efficiency of about 99 % has been achieved by using a coincidence setup with two layers of separate scintillators. The muon veto reduces the integral background rate recorded with the germanium detector by more than one order of magnitude by rejecting about 96 % of the muon-induced signals inside the germanium crystal.

The background with the finalized setup is lowered by more than three orders of magnitude compared to the unshielded case. The remaining integral background count rate between 40 keV and 2700 keV is 2.01(1) counts/(kg min), which is comparable to the background level of facilities with shallow overburden like the Felsenkeller in Dresden, Germany, with 100 mwe and 2.04 counts/(kg min), or the Garching Underground Laboratory in Garching, Germany, with about 10 mwe and 1.2 counts/(kg min). For comparison the rates are normalized to the detector crystal mass. Assuming a typical sample geometry, the detection limits can be calculated to be well below the design goal of 1 Bq/kg. Depending on the isotope under investigation, limits in the range of 10 mBq/kg can be reached with just one week of measurement time. In order to calculate activities, extensive Monte-Carlo simulations based on GEANT4 are performed to estimate and test the detection efficiencies.

The DLB enables radiopurity pre-screenings by the DIN ISO 11929:2011 standard within a short time period in order to decide whether a more sensitive but more expensive screening facility is necessary.

Currently, potential extensions of the facility are under investigation for further improvement of the spectrometry measurements, including pulse shape analysis with an FADC-based read-out system. Furthermore, Monte-Carlo studies are conducted to estimate the performance of an additional Anti-Compton shield to be integrated to the present setup.

About the Presenter

Christian Nitsch will be the presenter.

He is a PhD student in his second year and has been working on the Dortmund Low Background Facility (DLB) for the last four years. Whereas the focus for Bachelor's and Master's thesis (in the first two years) was on completing and upgrading the muon veto of the DLB, he is now operating the germanium detector, performing the measurements and working on further upgrades of the detector-system.

He is the primary author of a recent publication, which is presenting the status of the facility in 2015, before the completion of the muon veto.

Furthermore he is a member of the COBRA (neutrino-less double beta decay-search) collaboration and has performed on-site shifts at the LNGS, Italy, working on the upgrade of the COBRA demonstrator-setup.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **58**   Type : **Oral Presentation**

Reference Materials for Neptunium Determination

Monday, 26 September 2016 15:50 (0:20)

Content

Neptunium-237 is the longest lived isotope of neptunium, and is the parent nuclide of the '4n+1' decay series and is also produced in the decay of plutonium and americium:
Pu-241=>Am-241=>Np-237=>Pa-233=>U-233=>Th-229=>(5 alpha, 3 beta)Bi-209
Neptunium-237 has been produced in tonne quantities through the various global nuclear power programmes and has entered the environment from weapons test fall out and effluent from nuclear fuel reprocessing. In addition, measurement of Am241:Np-237 and Np-237:U-233 atom ratios can be used for age dating nuclear materials, and as one of the parameters contributing to the spatial attribution of nuclear material.

Although Np-237 has been produced in tonne quantities since 1945, it remains the least studied of the actinides between thorium and curium (with the possible exception of protactinium) and the analysis of Np-237 is complicated by difficulties in identifying a suitable isotope dilution tracer.

In the first part of this paper, we concentrate on the efforts being made to produce an isotope dilution tracer for mass spectrometry and the availability of suitable reference materials for 237Np analysis; this concentrates on nuclear forensics measurements based on mass spectrometry, but the lessons learned and the materials production routes are applicable to the wider community measuring Np-237 in different matrices for a variety of applications.

Then, the reasons for selecting Np-236 $(1.55(8) \times 105$ a) as the only practical isotope dilution mass spectrometry tracer for Np-237 will be briefly described.

Production of Np-236 by charged particle irradiation and fast neutron irradiation will be described, as well as the detailed separation and chemical processing and purification of this nuclide, utilising oxidation state control, solvent extraction and extraction chromatography will be examined in detail, as will the measurement of this nuclide by γ-spectrometry.

Some additional comments on other radionuclides generated as by-products of this process will also be made.

Finally, the current state-of-the-art will be summarised, along with the future plans for the routine production of Np-236 for use in nuclear forensics and other measurements.

About the Presenter

Simon Jerome has been a member of the NPL Radioactivity Group at NPL since 1989. In his time there, he has worked on many aspects of radionuclide metrology including:
Nationwide radioactivity measurement proficiency testing
Production of actinide tracers and standards
Radiochemical analysis techniques
Metrology supporting measurement of RADWASTE and NORM under the European Metrology Research Programme
In his current role as Head of Radiochemistry, he leads the NPL effort on metrology in support of threat reduction.

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Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **59**   Type : **Poster**

Environmental radioactivity study of forest ecosystems: long-term behaviour of contamination of wild boar and its radioecological coherences

Tuesday, 27 September 2016 15:02 (0:02)

Content

Thirty years after the Chernobyl accident on 26th of April 1986 the consequences are still noticeable and remain an important topic in the media and for society.

Although the consumption of mushrooms and game from European (Austrian/Bavarian) forests is no longer dangerous, in most cases, Cs-137 and Sr-90 can still be significantly detected. Cs-137 mainly occurs in mushrooms and flesh of game, whereas Sr-90 can be found in bones of game. Although there are many interesting areas of a forest to investigate, this work focuses on examining the amount of Cs-137 found in wild boar muscle and Sr-90 in wild boar bones. For Sr-90 in wild boar there are very few studies because, on one hand, less Sr-90 was emitted into the environment in Europe during the Chernobyl accident than Cs-137 and, on the other hand, Sr-90 in bones is not eaten. However, as a so-called bioindicator, Sr-90 is still highly useful for radioecological studies. To understand the interactions between the different parts of the forest, samples of soil and plants were also taken and measured for Cs-137 and K-40.

Cs-137 and K-40 in flesh were investigated by low-level gamma-ray spectrometry. Due to the sample inhomogeneity, uncertainties of the measuring geometry are estimated to be around 5%. These uncertainties are smaller than the relative measurement uncertainties of about 8-10%. The activity concentration of Cs-137 in muscle tissue found ranged from 14,9 Bq/kg (Wunsiedel, Bavaria) to 4711 Bq/kg (Weinsberger Forest, Lower Austria). 33% of the samples exceeded the regulatory limits of 600 Bq/kg for consumption in Austria and Germany.

The analysis of Sr-90 in bones was performed by Liquid Scintillation Counting (LSC) after radiochemical separation. The recovery of Sr-90 during chemical processing and separation was determined by the ICP-MS measurement of Sr-86 and Sr-88. Strontium recovery from the chemical processing before separation ranges from 90% to 95%, and from the separation itself is better than 85%, depending on the condition of the resin used. Due to low activities in the most samples, relative measurement uncertainties were between 15 and 18%. In the bones of wild boars, Sr-90 activity concentration ranged from 1,4 Bq/kg (Wunsiedel) up to 70,3 Bq/kg (Kobernausser Forest, Upper Austria). Also comparison of results to prior studies investigating Cs-137 and Sr-90 in wild boars, forest plants and fungi. It could be shown that contamination of wild boars with Cs-137 occurs mainly through consumption of fungi and wild berries, whereas Sr-90 is only taken up from the stalks and leaves of plants.

About the Presenter

The presenter holds a Master's degree in Physics from the Technical University of Vienna and is currently working as an intern at the International Atomic Energy Agency (IAEA) in the Terrestrial Environmental Laboratory.

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Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **61**   Type : **Oral Presentation**

Residual radioactivity of treated green diamonds

Tuesday, 27 September 2016 11:20 (0:20)

Content

Treated green diamonds from the diamond trade can show residual radioactivity, generally due to irradiation by direct contact with radium salts, usually RaBr2. This treatment, which is thought to be obsolete nowadays, was initially used to turn diamonds green, an attractive colour, by creating colour-centres in the diamond lattice with alpha particles in the few MeV range. The diamonds modified with this method are rare on the market but can represent, in some cases, a potential risk for consumer's health by direct irradiation or contamination when radium salt residues remain in the open cracks and cavities of the gemstone. In this paper we will report various activity measurements conducted on two radioactive diamonds: a 0.5-carat gem affected with high residual radium contamination and a seven-carat diamond with no residual radium contamination. In both cases, the activity was characterized by alpha and gamma-ray spectrometry, and the radon emanation was measured by defined solid angle alpha measurements of a frozen source. It appeared that, even when no residual radium contamination can be identified, a measurable alpha and high-energy beta emission can be detected. This emission is due to the implantation of solid radon daughters in the diamond lattice due to the recoil energy from the alpha transition. By radioactive decay, these radon daughters eventually decay towards 210Pb, a 22.3 years half-life radionuclide, producing by beta transition 210Bi, a high-energy beta emitter and 210Po, an alpha emitter. The implantation thickness of the radon progeny is small enough to allow the escape and detection of the particle emission from the diamond crystal. The paper also discusses the potential health impact of these radioactive diamonds and their status with regards the regulatory policy for radioactive products.

About the Presenter

Dr Philippe Cassette is an international expert of the French Atomic Energy commission, specialist of radionuclide metrology at the Laboratoire National Henri Becquerel, the National Metrology Institute of France. He published more than 60 papers in the field or radionuclide metrology and especially in the development of liquid scintillation counting techniques for radionuclide standardization.He is an associated member of ICRM.

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Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **62**   Type : **Oral Presentation**

Development of radiochemical analysis strategies for decommissioning activities

Thursday, 29 September 2016 09:00 (0:20)

Content

Decommissioning of the oldest nuclear power reactors is one of the most challenging technological legacy issues many countries will face in forthcoming years, as many power reactors reach the end of their design lives. These activities generate large amounts of waste that need to be classified according to their radioactive content. Approximately 10 % of the contaminated material ends up in different repositories (depending on their radioactive content) while the rest is decontaminated, measured and released into the environment or sent for recycling. Classification and control need to be done accurately in order to ensure that both the personnel involved and the population at large are not needlessly exposed to radiation or radioactive material and to minimise the environmental impact of such work. However, too conservative classification strategies should not be applied, in order to make proper use of the limited space available for radioactive waste repositories.

The information required by national authorities, especially in the early stages of the decommissioning process, includes a great number of radionuclides which, in the case of alpha and beta emitters, can only be determined after a radiochemical separation process. The paper presents the work carried out in the framework of the European Union funded project "Metrology for Decommissioning of nuclear facilities" (MetroDECOM) and deals with the development of procedures for the simultaneous determination of alpha and beta emitters in three matrices: concrete, steel and graphite. On the basis of individual sample treatment strategies which ranged from borate fusion to microwave assisted acid digestion depending on the different chemical properties of these matrices, we have worked to make these procedures merge in a common radiochemical analysis scheme based on extraction chromatography tandem arrangements for the simultaneous separation of up to four radionuclides.

In this presentation, the different methods will be described and the most significant achievements and pitfalls observed in the development and validation process will be discussed.

About the Presenter

PhD in Chemistry specialised in environmental radiochemistry and quality assurance. He works since 2012 at the Environmental Radioactivity Group of PTB in Braunschweig (Germany) and has been involved in diverse European Union funded research projects.

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Session Classification :   Radiochemical Techniques

Track Classification :   Radiochemical Techniques

Contribution ID : **64**   Type : **Poster**

Underground measurements of artificial radioactivity in squids from the western Pacific Ocean

Tuesday, 27 September 2016 15:04 (0:02)

Content

Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident discharged huge artificial radioactivity into the Pacific Ocean. To investigate its radiological effect on marine ecosystem, ash samples of squids from the western Pacific Ocean were prepared and measured by the underground gamma ray spectrometer — GeTHU. 108mAg, 110mAg, 134Cs and 137Cs were detected with maximum radioactivity values of 192.4 mBq/kg-wet, 19.3 mBq/kg-wet, 143.9 mBq/kg-wet and 33.9 mBq/kg-wet respectively, which indicates that the influence of FDNPP accident on marine orgasm is lasting but decreasing. The contrastive measurement with a ground spectrometer exhibited similar performance to GeTHU, as to the samples of this work whose own primordial radionuclides contributed dominatingly to the background. However, GeTHU is still a better choice in measurements of primordial radionuclides in samples or samples with ultra-low radioactivity and it will be continuously dedicated to the investigation of marine radioactivity from FDNPP accident in the future.

About the Presenter

MI, YuHao is a Ph.D. student at DEP of Tsinghua Uni, mainly engaged in the study of low background gamma ray spectrometers and application of HPGe detectors.

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Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **65**   Type : **Poster**

Application of thermogravimetric analysis for a high temperature combustion method of tritium analysis

Thursday, 29 September 2016 10:04 (0:02)

Content

There are the various forms of tritium in the environment. That can be classified as tissue free water tritium (TFWT), organically bound tritium (OBT) and total tritium with TFWT and OBT. TFWT which exists in the biological tissue is extracted by freeze-drying. After that, OBT can be extracted through combustion process for dry matter that has been washed repeatedly with TFWT. Various laboratories have used a number of different methods to analyze total tritium and OBT. These include oxidizer combustion, oxygen bomb combustion, plasma combustion and a high temperature combustion using tube furnace. In all methods, attention must be paid to two key points: complete combustion and prevention of contamination by ambient atmospheric moisture. One of those, a high temperature combustion using tube furnace is more efficient method for the limited samples and has been used a lot recently. However, there are problem of explosion and incomplete combustion for some environmental samples which include a large amount of organic matter. It cause flowing backward of tritium trapping solution and color quenching. So, this study applied thermogravimetric analysis (TGA) to a high temperature combustion using tube furnace for effective combustion without explosion and incomplete combustion. In this study, ignition points of samples were measured by making use of TGA for some samples which are nuclear waste (activated carbon, oil, resin, etc.) and environmental samples (potato, wheat, sediment, etc.). And, temperature steps of combustion method were determined in consideration of measured ignition points. Finally, we analyzed radioactivity of total tritium and OBT for each samples by combustion method applying the temperature steps. The reported mean values of tritium radioactivity were used to verify this method, and the results were in agreement with assigned radioactivity concentration in reference range. This study shows TGA of some nuclear waste and environmental samples and is aimed to demonstrate the process of stable and rapid combustion method.

About the Presenter

-

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Session Classification :   Radiochemical Techniques

Track Classification :   Radiochemical Techniques

Contribution ID : **66** Type : **Poster**

GAMMA3: latest improvements and coincidence measurements

Wednesday, 28 September 2016 14:48 (0:02)

Content

In the framework of the verification of international treaties, nuclear forensics or site survey, the detection and measurement of anthropogenic radionuclides at trace levels in the environment is of great interest. For constant improvement of these measurements, the CEA/DAM-Ile de France has developed a new versatile surface gamma spectrometer. Named GAMMA3, the spectrometer was installed in July 2013 at the low-level radioactivity laboratory of CEA/Bruyères-Le-Châtel. It features a specially designed shielding and three high purity germanium detectors (BEGe5030P type). Its radioactive background and its performance for measurement of traces of radioactivity by means of high efficiency gamma measurement were already presented (see [1], [2]).

Upgrades of the spectrometer's active shielding (cosmic veto and nitrogen injection) will be presented. These evolutions led to a normalized integral background count rate as low as 2.8 counts/min/kg(Ge) (from 40 to 2500 keV). This reduction of the integral count rate is mainly due to the upgrade of the cosmic veto which reduces it by a factor of 15. Because it involves up to three high purity germanium detectors, the spectrometer can be used to conduct coincidence measurements. In this case, recorded events have triggered a signal in at least two detectors simultaneously. Coincidence measurements are of great interest for searching the signature of a multi-gamma emitter radionuclide hidden in the gamma spectrum of active environmental samples. These can be fresh environmental filters, contaminated water volumes, soils etc. For a given radionuclide, coincidence measurements lead to reduced background count rates but also to lower detection efficiency. Their implementation is therefore controversial and must be optimized. It will be demonstrated that for specific multi-gamma emitters, an analysis methodology involving counts from multiple regions of interest can lead to an improved Minimum Detectable Activity (Co-60 for two regions, Cs-134 and Ag-110m for 4 to 6 regions). Sensitivity of the spectrometer (as a function of the total activity of the sample) for these radionuclides when performing direct or coincidence measurement will be compared.

[1]: A. Cagniant, et al. Appl. Radiat. and Isot., 98 (2015) 122-133.

[2]: A. Cagniant, PhD dissertation, Université Pierre et Marie Curie Paris 6 – France (2015).

About the Presenter

The presenter is Antoine CAGNIANT from CEA/DAM/DIF.

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Session Classification : Radiometrics

Track Classification : Radiometrics

Contribution ID : **67**   Type : **Poster**

Mathematical vs classical efficiency calibration in routine measurements of gamma emitting radionuclides in environmental samples

Wednesday, 28 September 2016 10:08 (0:02)

Content

High resolution gamma-ray spectrometry is a nuclear analytical technique widely used for a determination of radionuclides in wide range of their activities in various kind of samples, from nuclear waste samples to the environmental samples and foodstuffs. For the quantitative determination this technique requires a determination of a detector efficiency with a high accuracy. As the detector efficiency depends on an energy of emitted gamma rays, physical properties of materials and a sample geometry, calibration standards with same characteristics should be used for the efficiency calibration. However due to a large variety of the materials that have to be analysed, it is hard to obtain standard materials of the same characteristics. Therefore, the possibility to determine the detection efficiency in a mathematical way by detector and sample setup modeling can significantly facilitate the procedure. The aim of this work is to compare accuracy and precision of the radionuclide determination by using mathematical calibrations and classically source-based ones in routine measurements of specific environmental samples. As Canberra has developed Laboratory SOurceless Calibration Software (LabSOCS) for this aim, spectrometry setup, consisting of the Canberra broad energy germanium detector (BEGe) with the original lead shielding and Genie 2000, LabSOCS/ISOCS softwares are used for the quantitative determination of low-level activities in few specific matrices such as honey samples and borosilicate filters.

Monitoring of the environment pollution by anthropogenic radionuclides (such as the Chernobyl derived Cs-137) at different sites in Croatia is carried out over the years in our laboratory. It was found that ideal samples to reflect the radionuclide pollution over large areas can be honey samples. Namely, honey bees readily fly up to 4 km in all directions from their hive and thus have access to an area of about 50 square kilometers. In that way we get the best composited random sample. However highly representative samples do not guarantee accurate determination because it depends on a choice of the calibration standards. Since it is hard to obtain standards with the matrix of this type for the quantitative determination, materials with closest density to the measured sample, usually soil standards, were used. Therefore, obtained results of the radionuclide determination by classical calibration in honey were compared with results obtained with the mathematical calibration. Before that, an influence of a choice of the matrix composition in the mathematical calibration on the results is investigated. Several different matrix models are compared to find the best suiting mixture. The mathematically obtained efficiency calibration curves for this matrix are checked by inserting a small known amount of the standard with known activities into the same type of samples of honey. The influence of the homogeneity of the standard inserted in the sample is investigated too. Similar procedure is done for the borosilicate glass structure 0.7 µm pore size filter, 47 mm in diameter, 0.42 mm thick, placed in a plastic container. This type of samples can be used for the measurements of the radionuclides contamination in the air and applied in emergency situations, so it is important to have precise calibration curve. Accuracy and precision of the mathematical calibration are also tested with proficiency test samples of water and soil. All these results will be presented in the paper.

About the Presenter

I graduated at Department of Physics, Faculty of Science, University of Zagreb as a graduate engineer of physics (equaling to the Master of science in Physics level by the International classification) in 2011 and I enrolled in the PhD program at University of Rome „Tor Vergata", Faculty of science, Physics Department. I worked on my PhD thesis at the National Laboratories in Frascati, National Institute of Nuclear Physics, (LNF-INFN), with the KAONNIS Group lead by Dr. Catalina Curceanu working on kaon-nucleon/nuclei interaction in a framework of AMADEUS project. In 2015 I finished my PhD by defending the thesis titled „Studies of the [U+0245]-triton correlations in the low-energy kaon-nuclei interactions at DAΦNE with the KLOE detector". In july 2015 I started my work at the Ruder Boskovic Institute of Zagreb, Division for Marine and Environmental Research, in the Laboratory for radioecology where I am involved in determination of activity concentrations/massic activities of radioactive elements by high resolution gamma-spectrometry.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **68**   Type : **Oral Presentation**

SURROGATE POST-DETONATION URBAN DEBRIS (SPUD) STANDARD REFERENCE MATERIAL

Friday, 30 September 2016 09:00 (0:20)

Content

The characterization of urban debris after a nuclear weapon detonation is complicated by the high concentrations of elements like Ca, Fe, Al, and Si and other naturally occurring and anthropogenic materials that are entrained into the nuclear fireball from the local environment. Yet, this nuclear forensics characterization is essential in the identification of the fuel type, weapon design, production process and date, etc. The resulting nuclear forensics data must be accurate, precise, and anchored by validated measurement methods as conclusions drawn from these data will be coupled with law enforcement and intelligence information to identify those responsible. Reference materials (RMs) establish the traceability, accuracy, and precision of nuclear forensic measurements and provide the ability to benchmark measurement methods essential to meeting the requirements of legal scrutiny.

NIST, in concert with partner labs (AFIT (DoD), FBI (DOJ), and NPL) and with support from the FBI, have developed two Surrogate Post-Detonation Urban Debris (SPUD) Standard Reference Materials (SRMs) – SRM 4600 and 4601. The 4600 material is doped with natural Uranium and the 4601 material is doped with U235. These SRMs have been developed to mimic the "rubble" of a city after an Improvised Nuclear Device (IND) detonation, which is capable of producing fresh fission as well as activation products. For the first stage of SRM characterization, we have been assessing the homogeneity of the minor and trace elements in these SRMs by microbeam X-ray fluorescence (XRF) spectrometry and neutron activation/prompt gamma analysis, respectively. The primary goal of the homogeneity assessment is to determine the sample mass required for all elements to be homogeneous, with a secondary goal of determining this same minimum sample mass for the individual elements of interest. Results obtained from XRF analysis using PCA techniques suggest that a minimum sample mass of approximately 3 mg is required for all elements and sample masses of 0.1 mg up to 3 mg is required for the various elements of interest.

About the Presenter

Dr. Jacqueline Mann has over 18 years of inorganic elemental and isotopic analysis experience at the National Institute of Standards and Technology (NIST), with 14 of those years involving the certification of Standard Reference Materials (SRMs). She has worked on the development of new experimental design approaches and mass spectrometric techniques for concentration and isotopic measurements for improvement of measurement uncertainty. Currently, she is the lead SRM POC/SME in the NIST Radioactivity Group for the nuclear forensics community and is actively involved in the certification of SRMs/CRMs for Pre-Det and Post-Det nuclear forensics with fellow Federal agencies.

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Session Classification : Quality

Track Classification : Quality

Contribution ID : **69**   Type : **Oral Presentation**

Analysis of ultra-trace concentration of americium in sediments by HR-ICP-MS following a simple extraction chromatography separation

Thursday, 29 September 2016 09:20 (0:20)

Content

In radioecology, the measure of radionuclides in environmental samples is a key issue. The analysis of americium present at ultra-trace concentrations in sediments (˜mBq.kg-1) is often carried out by α-spectrometry after chemical separation. Americium is extracted from sample using a leaching process in 3M HNO3 then purified through co-precipitation and/or chemical separation using chromatographic extraction resins [1, 2, 3]. In general, the above procedure suffers from several drawbacks. It needs to use several resins, a long time consuming chemical separation step and a relatively long analysis time by α-spectrometry. The objectives of this study are to simplify the chemical separation procedure and to limit the analysis time using a high resolution plasma source mass spectrometry equipped with an APEX-Q (Elemental Scientific Inc.) high efficiency sample introduction system combined with a membrane desolvation unit (ACM). The separation is completed using a single chromatographic extraction column employing the N, N, N', N'-tetra-n-octyldiglycolamide (DGA) resin to separate ultra-trace concentrations of americium from the interfering polyatomic and isobaric elements (Bi, Pb, Tl, Hg, U) with minimal amount of major elements (Ca, Na, Mg, K ....). The chemical separation is performed following three successive washing steps, i.e. 3M HNO3 (removal of Tl, Pb, Mg, Al, Fe), 0.1M HNO3 (removal of U) and 0.1M HCl (removal of Ca and elution of Am) [4]. In order to limit the 238U peak tailing effect from ultra-traces of uranium on 241Am [5], a second purification step (U/Am) is performed after sample evaporation using the Evapoclean® device (Analab). The feasibility of the chemical approach was first assessed with synthetic solutions prior to the use of real leaching solutions (10 g of sediment per 50 mL of 3M HNO3) with recovery yields of $85.1 \pm 4.6\%$ and $56.1 \pm 2.0\%$, respectively. The methodology robustness was validated using certified reference material (AIEA 385). The concentration of americium equals to 4.69 ± 0.17 Bq.kg-1 agrees with the average certified 241Am value (4.31 Bq.kg-1), taking in account the confidence interval (4.26-4.48 Bq.kg-1). As a result, the proposed methodology allows to reduce the analysis time by a factor of about four with respect to that generally necessary for α-spectrometry assuming total analysis time of three weeks in order to achieve 1 mBq.kg-1 detection limit. The methodology was finally applied to assess the environmental level of contamination of 241Am in samples recovered from the Loire River estuary in order to fix a reference concentrations for sediments surrounding nuclear facilities in France. References [1] J. Eikenberg, M. Jaggi, H. Beer, M. Ruthi, I. Zumsteg, Separation techniques for low-level determination of actinides in soil samples, Applied Radiation and Isotopes, 67,(2009), 776-780. [2] J. Letho, X. Hou, Chemeistry and Analysis of Radionuclides, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2011. [3] M.H. Lee, E.C. Jung, W.H. Kim, K.Y. Jee, Sequential separation of the actinides in environmental and radioactive waste samples, Journal of Alloys and Compounds, 444–445, (2007), 544–549 [4] Z. H. Kazi, J. R. Cornett, X. Zhao, Liam Kieser, Americium and plutonium separation by extraction chromatography for determination by accelerator mass spectrometry, Analytica Chimica Acta, 829, (2014), 75-80. [5] G. Xiao, D. Saunders, R. L. Jones, K. L. Caldwell, Determination of 241Am in urine

using sector field inductively coupled plasma mass spectrometry (SF-ICP-MS), J. Radional. Nucl. Chem, 301, (2014), 285-291.

About the Presenter

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Session Classification :   Radiochemical Techniques

Track Classification :   Radiochemical Techniques

Contribution ID : **70**   Type : **Oral Presentation**

Operational and Simulated Background Characterization of an Ultra-Low Background Liquid Scintillation Counter

Wednesday, 28 September 2016 11:40 (0:20)

Content

The Ultra-Low Background Liquid Scintillation Counter developed by Pacific Northwest National Laboratory will expand the application of liquid scintillation counting by enabling lower detection limits and smaller sample volumes. Lower background count rates and lower detection limits can reduce the number of steps required for samples that require pre-concentration of the radionuclides. Environmental applications, such as testing of water samples, would particularly benefit from these capabilities. With background rates two orders of magnitude below the ~1 cpm background of commercially available low background liquid scintillation counters, the ULB LSC will push detection limits of a factor of 5 lower than currently achievable. A detection limit for the ULB LSC would be on the order of 0.25 Bq/L for a 10 mL water-borne tritium sample, 1000-minute sample and background count times, 20% counting efficiency for tritium, and a 50 counts per day (or 0.034 cpm) background. For the same parameters, the detection limit in a 1 cpm background instrument would be 1.27 Bq/L. The expected background of ~50 counts per day, based on initial testing and experimentally validated GEANT4 simulations, is achieved through graded passive shielding and active cosmic veto. Improvements to the light collection system will decrease the low energy threshold and increase in low energy (tritium) detection efficiency above the 20% observed with a partial build of the system. Tritium will be one of the benchmark tests for this system - for testing low energy collection efficiency, low energy spectral capabilities, and determining the low energy threshold of the detection system. The capabilities of the ULB LSC will be valuable for a variety of environmental applications, including examples such as the determination and analysis of organically bound tritium for understanding hydrologic and plant growth and intake processes and measurement of radon-222 and radium-226 in drinking water. The operational characteristics and initial test results of the ULB LSC will be presented alongside these examples of the additional capabilities available for radiation detection through liquid scintillation counting with the ULB LSC.

About the Presenter

Jennifer Erchinger is a Post-Master's Research Associate in the Radiation Detection and Nuclear Sciences group at Pacific Northwest National Laboratory, working towards finishing her Ph.D. in Nuclear Engineering with Texas A&M University in 2016. She graduated with by a B.S. in Chemistry from Texas A&M in May 2011, followed by an M.S. in Health Physics, with a focus on Nuclear Security, from Texas A&M in May 2013.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **71**   Type : **Oral Presentation**

Methods for Using Argon-39 to Age-Date Groundwater using Ultra-Low-Background Proportional Counting

Monday, 26 September 2016 11:00 (0:20)

Content

Argon-39 can be used as a tracer for age-dating glaciers, oceans, and groundwater to study the mean residence time (or age distribution) to better refine groundwater models. Multiple environmental tracers are used in groundwater modeling to cover a wide range of ages. Established tracers covering the age range of 50 years or less typically use H-3 (12.3 year half-life) or Kr-85 (10.7 year half-life) while the age range of 1,000 years or greater is covered by C-14 (5,730 year half-life). With a half-life of 269 years, Ar-39 fills an intermediate age range gap (50-1,000 years) to better define the age distribution of groundwater aquifers recharging on the time scale of 50-1,000 years.

Detection of Ar-39 depletion is challenging by direct beta counting. Currently only the deep underground laboratory in Bern and shallow underground laboratory at Pacific Northwest National Laboratory (PNNL) have demonstrated sufficient sensitivity for direct beta counting of Ar-39.

We present the methods employed for arriving at an age-date for a given sample of argon degassed from groundwater. This includes the degasification of groundwater, purification of the extracted gas, detector loading process, and data analysis techniques.

Groundwater samples were collected in collaboration with the U.S. Geological Survey (USGS) in Fresno, California (2014) and Modesto, California (2015). The degassed samples were shipped to PNNL and then processed to extract purified argon for direct beta counting in an ultra-low-background proportional counter (ULBPC) in PNNL's Shallow Underground Laboratory.

Prior to counting a groundwater sample, characterization measurements for each ULBPC are collected in the ultra-low-background counting system. Each ULBPC measures a geologic argon sample recovered from a carbon dioxide gas well, which represents the detector only background where no Ar-39 is present in the sample. A modern argon sample is also measured using commercial, atmospheric argon (containing "modern" levels of Ar-39). With these two bounding measurements of modern and geologic argon, we have defined the limiting cases for groundwater samples and thus, all groundwater samples will fall somewhere between the age range of modern and geologic argon.

An example of a groundwater age-dating measurement will be presented from end-to-end starting with the sample collection, to purification and detector loading, and finally to the measurement and analysis.

About the Presenter

Emily K. Mace is a Senior Research Scientist at the Department of Energy's Pacific Northwest National Laboratory (PNNL). She received her Masters in Physics from Purdue University in 2006. Ms. Mace has a background in radiation detector development and characterization. She has participated in growing the ultra-low-background capabilities of PNNL including characterization of the ultra-low-background proportional counters and the ultra-low-background counting system in PNNL's Shallow Underground Laboratory. In the Shallow Underground Laboratory, Emily measures samples in the ultra-low-background counting system for applications of environmental science and treaty verification. Emily

has also worked in safeguards to develop a UF6 unattended cylinder verification station (UCVS) for non-destructive assay of UF6 cylinders to verify U-235 mass using full volume measurement techniques. Emily has participated in field campaigns using the UF6 technology in deployments at both foreign and domestic enrichment facilities.

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Session Classification :   Radioactive Noble Gases

Track Classification :   Radioactive Noble Gases

Contribution ID : **72**   Type : **Poster**

Simultaneous, Dual-Isotope Measurement Approaches for Tritium and Radiocarbon by Ultra-Low-Background Proportional Counting

Wednesday, 28 September 2016 12:00 (0:02)

Content

Tritium and radiocarbon can be used as environmental tracers; by measuring both isotopes simultaneously, one can study how each isotope moves through a system relative to the other. Pacific Northwest National Laboratory (PNNL) has developed an ultra-low-background measurement capability which, when combined with their Shallow Underground Laboratory, provides enhanced capability to measure low-activity sources of tritium and radiocarbon simultaneously. Tritium levels have been steadily decreasing since atmospheric nuclear weapon testing in the 1960's and are now nearly back to pre-nuclear test levels (˜2-8 TU in rainwater). This makes a direct dual-isotope measurement difficult without additional chemistry to first concentrate the tritium in a sample.

Both tritium and radiocarbon can be collected in the form of methane from an environment of interest. This leads naturally to proportional counting as a direct measurement approach since methane samples can be loaded straight into a proportional counter with little or no sample chemistry required to increase concentrations or to separate isotopes for individual measurements.

There are detector specific characteristics that need to be known in order to simultaneously quantify the amount of tritium and radiocarbon present in a given sample. The detector background must be measured at the same pressure as the actual sample. Also, single-isotope standards must be measured in the same detector (also at the same pressure as the actual sample) in order to provide efficiency curves for each isotope individually. The latter is essential when quantifying the simultaneous measurement of tritium and radiocarbon since the beta end-point energies overlap (tritium beta end-point energy is 18.6 keV and radiocarbon beta end-point energy at 156.5 keV). In order to successfully decouple the two spectra, single-isotope measurements of each isotope individually are necessary.

Previous work has been performed at PNNL using modeling to decouple the tritium and radiocarbon spectra but the uncertainty in such models is high due to the complicated decay structure of radiocarbon. New work is in progress using single-isotope standards to directly measure the efficiency curves for both tritium and radiocarbon in an ultra-low-background proportional counter. This will allow for more accurate quantification of low-level tritium activities on top of a radiocarbon background.

We will present results of the single-isotope measurements used to decouple the simultaneous, dual-isotope measurement of a single methane sample. With this new information, we can identify sensitivity levels for the dual-isotope measurement in PNNL's Shallow Underground Laboratory.

About the Presenter

Emily K. Mace is a Senior Research Scientist at the Department of Energy's Pacific Northwest National Laboratory (PNNL). She received her Masters in Physics from Purdue University in 2006. Ms. Mace has a background in radiation detector development and characterization. She has participated in growing the ultra-low-background capabilities of PNNL including characterization of the ultra-low-background proportional counters and the ultra-low-background counting system in PNNL's Shallow Underground Laboratory. In

the Shallow Underground Laboratory, Emily measures samples in the ultra-low-background counting system for applications of environmental science and treaty verification. Emily has also worked in safeguards to develop a UF6 unattended cylinder verification station (UCVS) for non-destructive assay of UF6 cylinders to verify U-235 mass using full volume measurement techniques. Emily has participated in field campaigns using the UF6 technology in deployments at both foreign and domestic enrichment facilities.

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Session Classification : Radiometrics

Track Classification : Radiometrics

Contribution ID : **73**   Type : **Oral Presentation**

Improvements to sample processing and measurement to enable more widespread environmental application of tritium measurements

Tuesday, 27 September 2016 11:00 (0:20)

Content

Tritium measurements provide valuable insights into a variety of environmental studies including groundwater hydrology, oceanography, and limnology amongst others. This work describes efforts to use enhanced sample preparation and counting techniques to improve tritium measurement sensitivity in an effort to expand the role of these measurements in environmental studies. Historically, tritium measurements have been assisted by high amounts of anthropogenic atmospheric tritium released by above ground nuclear tests; thereby making tritium from environmental samples less challenging to detect. Since cessation of these tests, atmospheric tritium levels have decreased orders of magnitude from their peak in the 1960's and are now approaching levels of ˜ 2-10 tritium units (TU) in typical atmospheric rainwater. The resulting reduced tritium activity can complicate its effective measurement in environmental samples. In applications including different hydrologic and oceanographic studies, this can be addressed by simply collecting larger samples to compensate for lower tritium activity levels. If needed, these larger water samples can be concentrated using electrolysis under calibrated conditions to increase tritium concentration and thereby enhance ultimate measurement sensitivity and accuracy. In other cases, however, larger samples may not be logistically possible and effective application of tritium measurements becomes dependent upon improved analytical approaches to capture the shrinking tritium signatures needed for to environmental measurements. For instance, applications of organically bound tritium using microbial, plant, or animal biomass may be sample limited making it very difficult to rely on collecting more sample to overcome low starting tritium abundance. Studies focused on specific tissues (e.g. microbial biomarkers, plant growth rings, or specific animal organs) can thereby be restricted without an ability to make tritium measurements at very sensitive scales on small amounts of sample having near atmospheric concentrations of tritium.

Pacific Northwest National Laboratory (PNNL) has developed an ultra-low-background proportional counter method combined with measurement in the PNNL Shallow Underground Laboratory to enable analysis of small, low-activity tritium samples. In conjunction, sample processing approaches are being developed to enable conversion of multiple different types of environmental samples into the methane count gas used for proportional counter-based tritium analysis. Sample preparation follows three main steps: 1) environmental purification of the analyte of interest (biomarker, tissue sample, etc.), 2) combustion of the sample and collection of the resulting combustion water, and 3) chemical conversion of the combustion water to methane for isotope evaluation. These methods are designed to enable effective tritium measurements on less than one gram of modern, environmentally-derived, dry biomass samples at current atmospheric tritium levels.

We will use a demonstration of tritium measurements from a suite of water samples as an example to highlight the methane synthesis and counting approaches for measuring tritium content. Further, we will use this as a foundation for exploring additional uses of tritium in environmental applications.

About the Presenter

Dr. Moran specializes in analysis of active and stable light isotopes, including those of hydrogen, carbon, oxygen, and nitrogen. He has applied the measurement of these isotopes to a wide variety of ecology, microbial ecology, and forensic applications.

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Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **74**   Type : **Poster**

Characterisation of the natural radioactivity of the first geothermal installation in Flanders, Belgium

Friday, 30 September 2016 15:08 (0:02)

Content

Geothermal energy is a local source that is based on the heat generated by the earth. As the heat is continuously regenerated, geothermal exploitation can be considered as a renewable and, depending on the techniques used, a sustainable energy production system. With this respect, the Flemish Campine region has taken a pioneering role in the research on the use of deep geothermal energy. On September 2015, VITO, Vlaamse Instelling Voor Technologisch Onderzoek, decided to drill an exploration well with a planned depth of 3.5 km on the Balmatt site near Mol. The purpose was to demonstrate that it is possible in the Campine area to pump up hot water from a reservoir located in the Carboniferous Limestone Group for thermal use and electricity production. If tests meet expectations, it opens possibilities for the construction of dozens of geothermal power plants and for the creation of several heating networks in the provinces Antwerp and Limburg. The exploitation of geothermal energy is believed to cause little or no harm to the environment. Geothermal steam and hot water however do contain naturally occurring traces of gases, chemicals and radionuclides that could be harmful in high concentrations. Determining the radioactivity content of the formation water is important, since being in contact with the installation it may accumulate radioactivity in scales (NORM), e.g. by precipitation or radon decay. In geothermal installations with a high activity concentration of radium isotopes and their daughter products in the formation water (and the installation), monitoring and analysis of radiation is therefore required to ensure radiation protection of workers and the environment. During production tests on the first well at the Balmatt site, several formation water samples were collected in order to analyze their natural radioactivity content and chemical composition. From the chemical point of view it was revealed that the water has a high salt content with a chlorine concentration of 87 g/L. The activity concentration of 226Ra and 228Ra, was determined to be 108.85 $\pm$ 6.61 Bq/L and 24.54 $\pm$ 2.66 Bq/L, respectively. The decay products of 226Ra, such as 210Pb and 210Po were found to have a much lower concentration with values of 0.687 $\pm$ 0.037 and 0.036 $\pm$ 0.007 Bq/L, respectively. The activity concentration of U and Th isotopes was found to be low as well. The highest activity concentration of the thorium isotopes was found to be for 228Th (0.360 $\pm$ 0.070 Bq/L), which is normal since it is a decay product of 228Ra present in the water. In European regulations, geothermal installations have been included in the so-called Basic Safety Standards for Radiation Protection (EU Directive 2013/59/Euratom) as a NORM practice of concern to the Member States. At a Belgian level "geothermal energy production, including exploration and pumping activities in the development thereof" has recently been added as a NORM practice to national radiation protection legislation by the FANC-Decree of March 3, 2016, ensuring control of radiation protection by the national regulatory body (FANC) in the installations and in the safe disposal or discharge of solid and liquid residues which exceed the exemption criteria. The radiological characterisation of several geological samples obtained from different depths during the drilling, the formation water and suspended particles will be addressed in view of their impact on future exploitation of installations. Detailed description of the sampling, radiochemical and measurement methods applied and the associated challenges with the analysis of these samples will be discussed in the paper.

About the Presenter

M. Bruggeman

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Session Classification :   Special Session: Metrology of NORM

Track Classification :   Special Topic: Metrology of NORM

Contribution ID : **75**   Type : **Poster**

Study of particular problems appearing in NORM samples and recommendations for best practice gamma-ray spectrometry

Friday, 30 September 2016 15:00 (0:02)

Content

The applied raw materials and processed substances within Naturally Occurring Radioactive Materials (NORM) industries have a huge diversity regarding their chemical composition and physical nature. Due to this diversity, various problems may occur for gamma-ray spectrometry of NORM. Because of overlapping gamma-lines, X- and gamma-rays, or X-rays in coincidence, the aimed determination of specific radionuclides is challenging and requires suitable corrections for the different NORM samples. In order to perform traceable, accurate, and standardized measurements and to ensure a safe and cost optimized use of raw materials, products and by-products, improved measurement practices and procedures are required for NORM industries. Within the Joint Research Project IND57 MetroNORM in the framework of the European Metrology Research Programme (EMRP) the difficulties, which arise in the measurement of NORM samples are analyzed and new actions are proposed. This paper describes the study of spectral interference in selected NORM key-materials. Moreover, the improvement of measurement procedures based on gamma-ray spectrometry for NORM including the definition and testing of suitable correction factors is presented. For that purpose, two radon tight volumetric sources for measurement of the activity of each photon emitting nuclide in the sources were prepared. The sources were used to perform a intercomparison exercise, aimed to identify the main sources of interference and evaluate the applied methodology of the project partners. This included a critical peak-by-peak evaluation on spectral interference, self-attenuation, coincidence summing and counting statistics problems. Besides K-40 and La-138, the following gamma-emitting radionuclides of the natural decay series were part of the investigation: Ac-228, Bi-212, Bi-214, Pa-231, Pa-234m, Pb-210, Ra-223, Ra-226, Th-227, Th-230, Th-234, Tl-208 and U-235. Special attention was given to the radon tightness of the applied sample containers. Based upon the work, a proposal for solutions and recommendations for best practice gamma-ray spectrometry of the investigated NORM key-materials is given. The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.

About the Presenter

Prof. Dr. Franz Josef Maringer, Head Section Ionising Radiation at BEV/PTP to be skilled in radiation physics and measurements 30 years is delegate to the EUROMET/EURAMET TC Ionising Radiation; he is delegate to the CCRI(II)/BIPM; he is Secretary of the International Committee for Radionuclide Metrology (ICRM); he is member of the TC 'Radiation Protection' of the Austrian Standards Institute (ASI) and Vice-President of the Austrian Radiation Protection Association (OEVS). He is member of the Austrian Society of Medical Physics (OEGMP) and the International Union of Radioecologists (IUR); he is Associate Professor for radioecology and radiation metrology at the University of Natural Resources and Life Science Vienna (BOKU) and at the University of Technology Vienna (TU Wien)

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Session Classification :   Special Session: Metrology of NORM

Track Classification :   Special Topic: Metrology of NORM

Contribution ID : **76**   Type : **Poster**

Photon emission intensities in the decay of U-235

Wednesday, 28 September 2016 10:00 (0:02)

Content

Uranium-235 is the parent of one of the natural radioactive decay series and appears in the background of any spectrometer and is also classed as a NORM (Naturally Occurring Radioactive Material). Recommended photon emissions probabilities of 235U are based on the intensity of the 185.7-keV gamma-ray which is used to normalize relative measurements. In the evaluation performed in 2008 [1], only six independent measurements of the absolute emission intensity of the 185.7-keV gamma-ray were available, leading to the recommended value of 57.1 (3) %. In the frame of the European Metrology Research Project (EMRP) IND57 "MetroNORM" (Metrology for processing materials with high natural radioactivity), new measurements of the photon emission intensities in the decay of U-235 were conducted in order to improve the knowledge of the decay scheme. This is first based on the measurement of the reference 185.7-keV gamma-ray which overlaps with the 186.2 keV gamma-ray from 226Ra decay. Sources were prepared by EC-JRC IRMM, by deposition of a U-235 solution on glass plates. Standardization was carried out by alpha counting in a defined solid angle geometry. The reference activity was obtained with 0.7% relative combined uncertainty. Gamma spectrometry was performed using two high-purity germanium (HPGe) detectors: one for the low-energy range, and one for the high one, at different source-to-detector distances. Accurate efficiency calibration of the spectrometers was obtained with point sources, and the resulting relative combined uncertainty varies from 0.5–2%, depending on the energy range. Corrections for source geometry and coincidence summing effects were applied. The reference peak intensity was obtained with 1% relative combined uncertainty. The processing of the X-ray region included K and L lines: accurate deconvolution of the respective regions of interest was performed using COLEGRAM [2] to derive individual intensities, taking into account the natural line width of the X-rays. On the whole, about 60 gamma-rays in the decay scheme of U-235 and daughters were identified and quantified. These are presented and compared with the available recommended data.

[1] Bé, M.-M, Chisté, V., Dulieu, C., Mougeot, X., Browne, E., Chechev, V., Kuzmenko, N., Kondev, F. G., Luca, A., Galan, M., Arinc, A., Huang, X., Nichols, A., Table of Radionuclides, Monographie BIPM-5, vol.5, ISBN 13 978-92-822-2234- (Vol. 5) and 13 978-92-822-2235-5 (CD-Rom), CEA/LNE-LNHB, 91191 Gif-sur-Yvette, France and BIPM, Pavillon de Breteuil, 92312 Sèvres, France. /http://www.nucleide.org [2] Ruellan H., Lépy, M.-C., Etcheverry, M., Plagnard, J., Morel, J. (1996) A new spectra processing code applied to the analysis of 235U and 238U in the 60 to 200 keV energy range, Nuclear Instruments and methods in Physics Research A 369, 651-656.

About the Presenter

Current position: Research director at CEA (French Alternative Energies and Atomic Energy Commission)- In charge of gamma- and X-ray spectrometry in the Laboratoire National Henri Becquerel (laboratory of the French metrology institute)

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Session Classification : Radiometrics

Track Classification : Radiometrics

Contribution ID : **77**   Type : **Oral Presentation**

Consensus evaluation of radioactivity-in-soil reference materials in the context of an NPL Environmental Radioactivity Proficiency Test Exercise

Friday, 30 September 2016 11:20 (0:20)

Content

There is continuing need for reference materials to underpin measurements of a wide range of sample types encountered during the decommissioning of nuclear sites in the UK and overseas. Consultations between the National Physical Laboratory (NPL) and UK radioanalytical laboratories have identified concrete, soil, metal and oil as key generic sample types requiring measurement for the accurate categorisation of waste. This paper describes the development of two radioactivity-in-soil reference materials at NPL – one for peat and one for soil with high sand content. Each material originated from a larger bulk sample of the soil type concerned prepared around 30 years ago at a UK research laboratory for the measurement of radionuclide uptake in plants. The two materials were separately processed, subdivided and measured at NPL before being sent to laboratories participating in the 2013 NPL Environmental Radioactivity Proficiency Test Exercise. The assigned values for the activity concentrations of the radionuclides in the materials were determined by a 'consensus' evaluation of the results obtained from 21 laboratories (for 'sandy' soil) and 12 laboratories (for peat) using the method described previously by Harms and Gilligan*. Activity concentrations were derived for 90Sr, 137Cs, 239Pu and 241Am by taking the Weighted Mean of the Largest Consistent Subset (WM LCS) of the reported data. Overall, 69% of the data for peat were in agreement with the WM LCS; the corresponding figure for sandy soil was 57%. The project demonstrated the use of the NPL Environmental Radioactivity Proficiency Test Exercises as a mechanism for delivering reference materials to the user community.

- Harms, A. and Gilligan, C., Appl. Radiat. Isotopes, 68, (2010) 1471-1476

About the Presenter

Julian Dean has worked in the Radioactivity Group at the National Physical Laboratory since the late 1980s. He has specialised in the development of low-level radioactivity standards (gases, solutions and solids) and running national and international comparisons and proficiency tests in this field. He currently runs NPL's proficiency tests for radioactivity analyses at environmental laboratories and in nuclear site decommissioning.

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Session Classification : Quality

Track Classification : Quality

Contribution ID : **78**   Type : **Oral Presentation**

Efficiency computation for gamma-ray spectrometry assessment of samples with intrinsic inhomogeneity

Wednesday, 28 September 2016 09:20 (0:20)

Content

A Monte Carlo based tool for the evaluation of the efficiency and its uncertainty for the measurement of volume samples with activity and matrix inhomogeneity was developed. In this work we present the application of the tool to the evaluation of the efficiency for samples with an intrinsic inhomogeneity, such as various environmental samples. Usually environmental media are not homogeneous, comprising actually several elementary components, which may differ from each other in atomic composition, density and activity. The environmental samples extracted from these media inherit the inhomogeneity of the parent population. In the case of low activity samples, the particular distribution of activity may easily depart from a uniform distribution. The model of inhomogeneity implemented in the tool assumes that the medium is composed from a number of building blocks, all with the same dimensions; in each block the activity is uniformly distributed and the matrix is homogeneous; the probability of each building block to correspond to an elementary component (specific matrix and activity) is given. In order to evaluate the efficiency and to assess its uncertainty component due to the inhomogeneity-related sampling uncertainty, the following procedure is applied. Using the Monte Carlo method, a large set of samples simulating the probes to be measured is drawn from the parent population. The samples differ with respect to the number of blocks of each type, as well as to their spatial distribution. For each sample from the set the efficiency is evaluated using the GESPECOR code. After processing all the samples, the distribution of the efficiency values is obtained and summarized, the mean value and standard uncertainty being reported. As an example, the application of the tool in the case of a soil sample which includes grains of pitchblende (with higher specific activity and self-attenuation) is presented. It is assumed that the sample is measured with a n-type HPGe detector. The elementary components of the sample considered are common soil, pitchblende and air. Several dimensions of the building blocks are selected, as well as several values of the probability of each component. In each case a large set of sources, with activity and matrix distribution sampled from the corresponding population, are prepared. For each source the full energy peak efficiency for the energies E=46.539 keV, 92.59 keV, 186.211 keV and 1001.030 keV is evaluated and finally the distribution of the values of the efficiency for all the sources from a set is constructed. Generally, the distribution of the efficiency values is sensitive to the spatial distribution of the activity, thus to the distribution of pitchblende grains, which represent the highest activity blocks. Due to the much stronger self-attenuation of low energy photons in pitchblende grains than in soil grains, the distribution of the efficiency values at 46 keV depends significantly on the number of pitchblende grains from the source; as expected, it decreases with this number, thus with the total activity of the source. In addition, the distribution of the values of the efficiency is studied (a) as a function of the dimensions of the elementary blocks, for fixed values of the probability of each component; (b) as a function of the probability of pitchblende blocks, for blocks of fixed dimensions. Thus a detailed picture of the effects of source inhomogeneity on the uncertainty of the efficiency is obtained.

About the Presenter

Octavian Sima is a professor of nuclear physics at the Physics Department of the Univesrity of Bucharest. He is currently the coordinator of the Gamma-Ray Spectrometry Working Group of the International Committee for Radionuclide Metrology.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **80**   Type : **Poster**

PRODUCTION OF SPIKED VEGETATION SAMPLES CONTAINING GAMMA-EMITTING RADIONUCLIDES TO PARTICIPATE IN PROFICIENCY TESTING PROGRAMS

Friday, 30 September 2016 10:00 (0:02)

Content

The production of environmental samples such as soil, sediment, water and vegetation with radionuclides for intercomparison tests is a very important contribution to environmental monitoring. Laboratories that carry out such monitoring need to demonstrate that their results are reliable. The National Laboratory for Ionizing Radiation Metrology (LNMRI) by means ofNational Intercomparison Program (PNI) produces and distributes environmental samples containing radionuclides used to check the environmental measurement laboratory performances. This work demonstrates the feasibility of producing vegetation (grass) samples containing 60Co, 65Zn, 134Cs, and 137Cs by the spiked sample method for the PNI. The preparation and the statistical tests followed 34 and 35 ISO Guiderecommendations. The grass samples were dried, ground and passed through a sieve of 250 μm. 500 g of vegetation was treated in each procedure. Samples were treated by two different procedures: homogenizing of the radioactive solution containing vegetation by hand and drying in an oven; and homogenizing of the radioactive solution containing the vegetation in a rotatory evaporator and drying in an oven. The reference values for activity concentration of the radionuclides in the grass had a range of 593 Bq/kg to 683 Bq/kg. After gamma spectrometry analysis the results of both procedures were compared as accuracy, uncertainty, homogeneity and stability. The accuracy, uncertainty and short time stability from both methods were similar but the homogeneity test of the evaporation method was not approved for the radionuclides 60Co and134Cs. Both procedures of preparation showed similar results, with values close to the reference.The main differentiating factor was the homogeneity, in which the agitation proved to be more homogeneous than the evaporation procedure.The homogenization of the solution into the distillation flask from the rotary evaporator was not effective because it does not convey the agitation of the solution for the whole container. Based on comparisons between procedures was chosen the manual agitation procedure for the grass sample. The accuracy of the procedure had a range between -1.1 and 5.1% and the uncertainty between0.6 and 6.2 %. This result show is the procedure chosen for the production of spiked grass samples for PNI.

About the Presenter

My name is Poliana Santos de Souza,I'm brazilian, I live in Rio de Janeiro, Brazil. I graduated from University Unigranrio in chemistry. I finished the master's degree in radiation protection and Dosimetry in the area of metrology, Institute of radiation protection and Dosimetry. My professional goal is an opportunity in a chemical or nuclear, so that I can put into practice the knowledge acquired and obtain new knowledge. At work, I try to be considerate. And I have easily to work in group, if necessary.

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Session Classification :   Quality

Track Classification :   Quality

Contribution ID : **81**   Type : **Poster**

Analysis and Evaluation for Consumer Goods containing NORM in Korea

Friday, 30 September 2016 15:04 (0:02)

Content

To protect the public from natural radioactive materials, the "Act on safety control of radioactive rays around living environment" was established in Korea focusing on natural resources, byproducts, products, and cosmic rays. For products, not only building materials containing NORM, as special case founded in Korea, some consumer goods to promote health such as anion bracelets, necklace and mats contain naturally occurring radioactive material (NORM). Some of them can cause problems by high radioactivity. In the regulations, there is an annual effective dose limit of 1mSv for products, but the activity concentration limits is not established yet. To derive the activity concentration limits for products, it is necessary to analyze the radioactivity for used products and to evaluate the dose by products using usage scenario. In the case of building materials, room models to predict the external exposure by gamma radiation from building materials have been developed and used in the last 20 years. However, for the consumer goods in contact with bodies, because they have a variety of shape, size and usage position, it is very difficult to evaluate the exposure dose by each consumer goods. In this research, we analyzed twenty consumer goods such as anion bracelets, necklace and mats sold by on-line market in Korea and evaluated the external dose. In the case of radioactivity measurement, we analyzed the U238 and Th232 using the Inductively Couples Plasma-Mass Spectroscopy (ICP-MS) instead of gamma spectroscopy because of small quantities. The analysis results are from 1.11 Bq/kg to 2810 Bq/kg for uranium and from 0.54 Bq/kg to 11859 Bq/kg for thorium. For dose evaluation by consumer goods, we assumed the "small room model" surrounding the ICRP reference phantom to simulate the consumer goods in contact with bodies, from the idea of room model. We reduced from the room size to phantom size and assumed the thickness from 0.001 cm to 1 cm considering usage quantities. It is possible to evaluate any type of consumer goods using this model and to derive activity concentration limits considering usage quantities. Using the Monte Carlo code MCNPX, we evaluated the effective dose rate for the ICRP reference male in a small room model. The results are from 7.67E-14 to 7.57E-11 Sv/h per Bq/kg for uranium and from 1.07E-13 to 1.05E-10 Sv/h per Bq/kg for thorium. Using the analysis results and the effective dose rate, we calculated the effective dose by consumer goods assuming usage time and derived the activity concentration limits.

About the Presenter

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Session Classification :   Special Session: Metrology of NORM

Track Classification :   Special Topic: Metrology of NORM

Contribution ID : **82**   Type : **Oral Presentation**

The BiPo-3 detector

Wednesday, 28 September 2016 09:40 (0:20)

Content

The BiPo-3 detector, running in Canfranc Underground Laboratory (LSC, Spain) since 2013, is a low radioactive detector dedicated to measure ultra high natural radiopurity in ^{212}Bi (^{228}Th) and ^{214}Bi (^{226}Ra) of thin materials. The ^{208}Tl and ^{214}Bi isotopes, which belong to the natural radioactive chain of U and Th, are the two main background isotopes in the search for the neutrinoless double decay. The BiPo-3 detector has been initialy developped to measure the radiopurity of the selenium double β source foils of the SuperNEMO experiment. In order to measure the ^{208}Tl and ^{214}Bi contaminations, the underlying concept of the BiPo-3 detector is to detect the so-called BiPo process, which corresponds to the detection of an electron followed by a delayed α particle. In this novel experimental technique the foil of interest is installed between two thin ultra-radiopure plastic scintillators. The ^{208}Tl and ^{214}Bi contaminations are then measured by detecting the β decay as an energy deposition in one scintillator without a coincidence from the opposite side and the delayed α as a delayed signal in the second scintillator without a coincidence in the first one. The timing of the delayed α depends on the isotope to be measured. The BiPo-3 detector is composed of two modules. Each module consists of two rows of 20 pairs of optical sub-modules. Each optical sub-module consists of a polystyrene-based scintillator plate coupled with a PMMA optical guide to a 5 inches low radioactive PMT. The optical sub-modules are arranged face-to-face to form a pair. The size of each scintillator is 300x300x2 mm^3. The BiPo-3 detector corresponds to a total number of 80 optical sub-modules and a total surface area of measurement is 3.6 m^2. The experimental design and performances of the detector are presented. Dedicated background measurements have been performed. After an exposure of about 2 years.m^2 , the surface activities of the scintillators of A(^{208}Tl)=0.9 $\pm$ 0.2 μBq/m^2 and A(^{214}Bi) = 1.0 $\pm$ 0.3 μBq/m^2 are reported. The average rate of random coincidences is 6 . 10^{-4} cts/day/m^2 of surface area of scintillator for the ^{208}Tl measurement, and 0.12 cts/day/m^2 for the ^{214}Bi measurement. The validation of the BiPo-3 measurement with a calibrated aluminium foil is presented. Results of the ^{208}Tl and ^{214}Bi activity measurements of the first enriched ^{82}Se foils of SuperNEMO are reported.

About the Presenter

Pia Loaiza field of expertise is the low radioactivity assay for dark matter and neutrinoless double-beta decay experiments. She was involved in the Edelweiss dark matter experiment and is currently a member of the SuperNemo collaboration. She has previously worked in ultra-low background gamma spectrometry and she has developped two low background HPGe detectors which are installed in the Modane Underground Laboratory. Since 2012 she has joined the SuperNemo double beta experiment and she is in charge of the BiPo detector.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **83**   Type : **Oral Presentation**

STATE OF THE ART ANALYSIS OF RADIOXENONS AND KRYPTON-85 AT THE BFS NOBLE GAS LABORATORY

Monday, 26 September 2016 11:40 (0:20)

Content

Since the early 1970s the noble gas laboratory of the German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) operates laboratory based measurement systems to determine the activity concentrations of krypton-85 (85Kr) and radioxenon, mainly xenon-133 (133Xe) in air. After cryogenic adsorption/desorption of the noble gases, followed by gas-chromatographic separation of krypton and xenon, these systems measure the beta decays in proportional counters, housed within an anti-coincidence system and a 10 cm lead shield. The minimum detectable activity (MDA) for this method is 0.01 Bq for 133Xe and 0.03 Bq for 85Kr in 1-2 m3 of air, the minimum detectable concentration (MDC) for a typical 10 m3 weekly sample is 1 mBq•m-3 and 6 mBq•m-3, respectively. In 2014, this method was accredited according to DIN EN ISO/IEC 17025, and a strict quality assurance program including internal and external quality controls are in place, in accordance with the requirements for the accreditation.

A SAUNA (Swedish Automatic Unit for Noble Gas Acquisition) laboratory noble gas system was installed at the BfS laboratories in 2009. This system is capable of measuring Xe-isotopes 133Xe, 135Xe, 133mXe and 131mXe in air samples simultaneously and is routinely used within the laboratory's role as a Support Laboratory for the Provisional Technical Secretariat (PTS) of the Comprehensive Test Ban Treaty Organisation (CTBTO). As with the conventional systems above the amount of stable Xe is determined using gas chromatography, but activities of the individual Xe-isotopes are measured using beta-gamma coincidence techniques, with an MDC one order of magnitude below that of the conventional proportional counters. While the lower MDC allows characterization of the background and its variability, which is typically close to the MDC of the conventional system for most environmental sites, the ability to measure four Xe-isotopes simultaneously allows isotopic source discrimination. Consequently, the SAUNA system is increasingly used for routine analyses of samples from the BfS' national and international noble gas network, with contributing partner institutions at more than 10 stations (as of January 2016), and accreditation of this system is envisaged within the next couple of years.

In this paper the systems, their advantages and improvements will be described, with an emphasis on internal and external quality controls, accuracy and repeatability. Results of comparative analyses of routine samples, standards and samples from Proficiency Test Excercises (PTE) organized by the CTBTO will be shown. Examples will be given to highlight the information gained from long time-series of Xe activity concentrations in the atmosphere coupled with isotopic information through routine analyses for 133Xe, 135Xe, 133mXe and 131mXe.

About the Presenter

Dr Clemens Schlosser works with the German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) and is the head of BfS' Noble Gas Laboratory in Freiburg, Germany. Clemens oversees the global noble gas monitoring network of the BfS and has more than 25 years of experience in the measurement of radioactive noble gases. His experience as radionuclide expert is sought as an adviser to the German Foreign Ministry

and Permanent Mission of the Federal Republic of Germany to the Office of the United Nations and to other International Organizations. Clemens was the project leader for the BfS part of the CTBTO's International Monitoring System (IMS) Noble Gas Equipment Test (INGE).

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Session Classification :   Radioactive Noble Gases

Track Classification :   Radioactive Noble Gases

Contribution ID : **84**   Type : **Poster**

International Rn-222 in drinking water interlaboratory comparison

Friday, 30 September 2016 12:02 (0:02)

Content

Radon in domestic water supplies can cause human exposure to a radiation dose through inhalation and ingestion.

In 2013, the European Commission published a Directive (ECDWD) outlining requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption. This Directive states that remedial action is deemed to be justified on radiological protection grounds where radon activity concentrations in drinking water exceed 1000 Bq/l. It also states that the measurement technique must be "reliable and comparable" and "have a system of analytical quality control that is subject to checking".

The Environmental Protection Agency, Ireland (EPA) has a radon in water measurement technique accredited to ISO 17025. As a result of this, and the requirements outlined in the new ECDWD, the EPA are required to demonstrate on-going proficiency of the analytical method through participation in proficiency tests (PT) and interlaboratory comparisons (ILC). However, there is a considerable lack of relevant PT schemes and ILCs available for radon in drinking water analyses for the EPA to participate in. Therefore, the EPA conducted its own ILC for radon in water in 2014 in conjunction with eight other laboratories from Ireland, Norway, Finland, Estonia, Spain and Portugal.

The water supply chosen for the ILC was a private drinking water supply with a radon activity concentration of between 500 Bq/l and 1000 Bq/l. A radon activity concentration in this range would determine whether the participating laboratories could demonstrate a proficiency of measurement close to the remediation action level of 1000 Bq/l. It also ensures that the radon activity concentration of the samples would not decay sufficiently, between sampling and the delivery of sample to the participating laboratories, to be below limits of detection.

The samples for the ILC were all taken on the same morning in October 2014. The samples taken used the EPA's standard sampling protocol for radon in water analysis, unless otherwise specified by a participating laboratory. Samples were also taken for homogeneity checks during the sampling period. The samples were then dispatched by courier to all participating laboratories and were received within 48 hours. Results from participating laboratories were then submitted within three months of the sampling date. The radon in water results from each laboratory were collated and the data was interpreted in order to determine whether the results were in agreement with each other. The homogeneity of the samples were also checked and the sample set was found to be homogeneous.

The results submitted by the participating laboratories were compared using ISO 13528 "Statistical Methods for use in proficiency testing by interlaboratory comparisons". Each result submitted by a laboratory was compared to the consensus value of 606 ± 12 Bq/l (k=1). The submitted results were assigned an overall classification based on the combination of their z-score, En-score and an outlier test.

In total, 16 measurement results were submitted by the participating laboratories. Twelve of the measurement results submitted are in agreement with the assigned value, with four of the results deemed questionable. Although three of these four results do not deviate significantly from the assigned value, the calculated En-score values (less than 1), could be indicative that the measurement uncertainties associated with these results are too small.

The results from this ILC indicate that there is good agreement between the participating laboratories for radon in water measurements.

About the Presenter

Kevin Kelleher is the manager of the radiochemistry laboratory in the Office of Radiological Protection of the Environmental Protection Agency, Ireland. Kevin has worked in the radiochemistry laboratory since 2005 and oversees the environmental radioactivity monitoring programmes of the EPA as well as maintaining the radiochemistry laboratory's ISO 17025 accreditation. This work includes the development and validation of new radiochemical techniques and participating in proficiency testing schemes and interlaboratory comparisons. Kevin has also been an international expert on several IAEA missions to Japan, participating in an international interlaboratory comparison on marine samples taken off the coast of the Fukushima Dai-ichi nuclear power plant and has advised the Fukushima prefecture government on how best to map and display monitoring and measurement data in the Fukushima prefecture. Kevin is Ireland's representative on the European Commission's Articles 35 and 36 Expert Group and a member of the European Radioecology Alliance.

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Session Classification : Quality

Track Classification : Quality

Contribution ID : **85**   Type : **Oral Presentation**

Monte Carlo simulation of air sampling methods for the measurement of radon decay products

Monday, 26 September 2016 10:40 (0:20)

Content

Frequently the air concentration of radon decay products is assessed by sampling a certain volume of air through a filter. The activity collected on the filter is measured according to an appropriate protocol, which is defined by the measurement channels, with specific detection efficiency of each decay product, and by the measurement intervals. The relations between the concentrations and the measurement results are then used for obtaining the concentrations. In a previous study, this approach was implemented in a least squares computer code for the calculation of the concentrations of 222Rn and 220Rn decay products [1].The code can be applied for a broad range of measurement protocols. The uncertainty of the results is evaluated by assuming Gaussian distributions and the propagation of variances. The current requirement for realistic evaluation of the uncertainties of the measurement results, as well as the construction of a radon chamber in IFIN-HH (Bucharest, Romania), renewed our interest for this problem. In the present work we develop a more realistic procedure for the evaluation of the uncertainties of the activity concentrations of radon decay products measured by air sampling methods. The procedure is based on Monte Carlo simulation and propagation of the distributions, in accord with GUM Supplement 1 [2]. In essence, a large set of simulated numbers of counts corresponding to a given measurement protocol is generated, the activity values are calculated for each set and finally the distribution of these values is constructed. The model applied for the preparation of a sample of the numbers of counts has the following main features. The radon concentration is considered stationary in a given volume. The average concentration of each decay product in the air is characterized by the corresponding equilibrium factors. However, as a result of the statistical processes of production and decay, the number of radioactive nuclei of any type in the volume is a random variable. Assuming that there is no correlation between the numbers of nuclei in disjoint volumes, the distribution of the number of nuclei in any volume can be computed. Then the number of nuclei from the air volume pumped in an elementary filtration act and collected on the filter can be appropriately sampled by Monte Carlo techniques. Next the random decay of these nuclei and the detection processes are simulated in a standard way, recording the number of counts in the appropriate measurement channels and time intervals. The air sampling procedure is repeated by a number of times corresponding to the duration of air filtration. Finally, by counting the number of signals accumulated in each measurement channel in each measurement interval, a particular sample of the number of counts is obtained. The procedure developed can provide a realistic description of the uncertainties of the activity concentrations of the radon decay products. It can be used also for optimizing the parameters of the measurement protocol. [1]. O. Sima, Comprehensive software for the assessment of 222Rn and 220Rn decay products based on air sampling measurements,Appl. Radiat. Isot.67 (2009) 867-871 [2]. JCGM 101:2008, Evaluation of measurement data – Supplement 1 to the "Guide to the expression of uncertainty in measurement" – Propagation of distributions using a Monte Carlo method

About the Presenter

Octavian Sima is professor of nuclear physics at the Physics Department, University of Bucharest, Romania. He is currently the coordinator of the Gamma-Ray Spectrometry Working Group of the International Committee for Radionuclide Metrology.

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Session Classification : Radioactive Noble Gases

Track Classification : Radioactive Noble Gases

Contribution ID : **87**   Type : **Oral Presentation**

Intrusion of Fukushima-derived radiocesium into the Arctic Ocean from the Bering Sea in summer 2014

Tuesday, 27 September 2016 14:00 (0:20)

Content

Accident of Fukushima Dai-ichi Nuclear Power Plant (FNPP1) in March 2011 resulted in a large amount release of radiocesium (Cs-134 and Cs-137) into the North Pacific Ocean and its adjacent seas. Oceanographic observations have revealed that the Fukushima-derived radiocesium has been transported eastward along surface currents and southward due to subduction of mode waters in the North Pacific Ocean. However, spreading of the radiocesium into the Bering Sea and Arctic Ocean is not understood well. During the summers of 2012, 2013, and 2014 we measured activity concentration of radiocesium in seawater samples from surface layer in the subarctic North Pacific Ocean, Bering Sea, and Arctic Ocean and from surface to about 800 m depth in the Canadian Basin in the Arctic Ocean. The seawater samples (20-40 liter) were collected using a bucket or a pump for the surface water and Niskin Sampler for the deeper water. Some of them were filtrated and all the samples were acidified with nitric acid on board. In laboratories on shore, radiocesium in the sampled seawater was concentrated onto ammonium phosphomolybdate (AMP). Radiocesium in the AMP was measured using ultra-low-background gamma-ray detectors in Low Level Radioactivity Laboratory, Kanazawa University and Mutsu Institute for Oceanography, Japan Agency for Marine-Earth Science and Technology. Uncertainty of the radiocesium measurement was estimated to be about 8 %. In the Arctic Ocean, about 1.5 and 3.5 Bq/m3 of Cs-137 were observed in surface layer from sea surface to about 200 m depth and subsurface from about 200 m to 800 m depth, respectively, in the each year. Because similar vertical profiles of Cs-137 were observed in the Arctic Ocean before the FNPP1 accident, these could be derived from nuclear weapon testing in the atmosphere mainly in the 1950-60s and release from nuclear fuel reprocessing plants into the North Atlantic Ocean mainly in the 1980-90s. Fukushima-derived Cs-134 was not detected in 2012 and 2013 while a low concentration (0.07 Bq/m3) was measured at 150 m depth only in summer 2014. The depth of 150 m corresponded to a temperature minimum layer originated from seawater from the Bering Sea. On the other hand, Cs-134 activity concentrations less than 0.3 Bq/m3 were observed in surface seawater in the Bering Sea in 2012, 2013, and 2014. These results imply that the Fukushima-derived Cs-134 was transported from the Bering Sea to the Arctic Ocean through the Bering Strait about 3.5 year after the FNPP1 accident. This work partially supported by Grant-in-Aid for Scientific Research on Innovative Areas, the Ministry of Education, Culture, Sports, Science and Technology Japan (KAKENHI), No. #24110005.

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Session Classification : Applications

Track Classification : Applications

Contribution ID : **89**   Type : **Poster**

Measurement system of alpha and beta emitters with continuous air sampling under different exposure situations

Tuesday, 27 September 2016 12:04 (0:02)

Content

After Fukushima nuclear accident occurred in 2011, prompt detection of radioactive plume has been required for safe evacuation of general public in the framework of nuclear disaster prevention. As the System for Prediction of Environmental Emergency Dose Information (SPEEDI) was not well functioning at that time, the Nuclear Regulation Authority in Japan decided not to use the system any longer when judging whether the evacuation is needed or not. From such circumstances, many measuring devices for radioactive plume detection need to be widely deployed around nuclear facilities. It is well known that most of artificial radionuclides emit beta particles as well as gamma radiations and therefore a measurement system has been set up so as to detect beta particles promptly with continuous air sampling. This system consists of a silicon semiconductor detector, a pre-amplifier, a linear amplifier and a multi-channel analyzer. The detection head accommodates a filter holder which the detector faces for continuous air sampling. In the present study, the following subjects were discussed: 1) selection of proper filter, 2) Optimization of beta detection, 3) Application to radon progeny measurements. For the selection of proper filter, we examined three types of filter: membrane (Millipore series), glass fiber (Whatmann series) and HE-40T (Japanese standard, JIS Z4601). The geometric arrangement of the detector and filter was optimized. For radon progeny measurements with continuous air sampling, detection of alpha particles was used by the semiconductor detector. In addition, a special algorithm for potential alpha energy concentration (PAEC) was installed in this system (Tokonami et al., Health Phys. 1996).

About the Presenter

Shinji Tokonami, Ph.D. is a professor at Hirosaki University in the Department of Radiation Physics and specializes in radiation measurements and measurement procedures. In 1995 Dr. Tokonami earned his Ph.D. in engineering from Waseda University. Throughout his career he has been involved with radiation research at Waseda University, the National Institute of Radiological Sciences, and Hirosaki University. In addition, he is also a member of several International Organizations for Standards' committees regarding radon and radiation measurements.

Dr. Tokonami also has developed multiple measurement techniques and equipment related to his field. In particular he developed a special algorithm for determining airborne radon decay products with continuous air sampling and established a passive measurement technique for determining two radon isotopes (radon-222 & -220) separately. After the Fukushima nuclear accident, he is currently working on a quick and effective technique to measure radioactivity in the thyroid to determine the dose and quantify the radiological impact due to a nuclear accident.

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Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **91**   Type : **Poster**

Continuous measurement of radon exhalation rate from soil surface around active volcano

Monday, 26 September 2016 12:00 (0:02)

Content

There are many active volcanos in Japan. In particular, the Sakura-jima volcano, which is located at southern Japan, has been very active since 2009. High 210Po activity concentrations have been observed in air samples from Sakura-jima volcano collected in the 1980s. 210Po is one of the decay products of 222Rn which is a radioactive noble gas. 222Rn is normally generated by radioactive decay from 226Ra in materials such as soil and rocks. Thus, high 222Rn may have been observed from Sakura-jima volcano when the high activity concentrations of 210Po were measured. Radon inhalation, which includes 222Rn, 220Rn and their decay products, is believed to increase the risk of lung cancer and is second only to tobacco smoking as a risk factor. It has been previously reported by Darby et al. that the relative risk of lung cancer increases 16% per 100 Bq m-3 indoor radon activity concentration. Recently, the WHO proposed a reference level for indoor radon gas ranging from 100 to 300 Bq m-3. On the other hand, the phenomenon of increasing outdoor 222Rn activity concentrations before earthquakes associated with diastrophism has been reported by many researchers. This phenomenon was explained as follows: the micro-crack was generated by stress to the crust, and radon in the rocks was reached to the ground surface through the micro-crack. That is, increases in 222Rn activity concentrations from the soil surface might be associated with the diastrophism caused by the volcanic activity. This may suggest that the increases in 222Rn activity concentrations associated with the activity of the Sakura-jima volcano may be increasing the lung cancer risk for people living nearby. Thus, continuous measurement of 222Rn activity concentrations from the soil surface may be useful from the viewpoint of health physics and the prediction of volcanic activity. For this monitoring, a continuous measuring system of 222Rn exhalation rate from the soil surface was developed using a ventilation-type accumulation chamber and pulse-type ionization chamber. This system was set at Tarumizu City in Kagoshima Prefecture which is located at approximately 10 km south-southwest of Sakura-jima. 222Rn exhalation rate is influenced strongly by the water content in soil. Thus, the volumetric water contents in depth from the ground surface of 10, 20, 30, 40, 60, and 100 cm were also measured continually at the same measurement site. The soil temperature is one of the main influences on the emanation and diffusion of 222Rn in soil. Thus, the soil temperatures in depth from the ground surface of 10, 40, and 100 cm were also measured continuously. Furthermore, meteorological data such as temperature, humidity, atmospheric pressure, wind speed and precipitation were also observed in the present study. We will present the relationship between the 222Rn exhalation rate from the soil surface and the meteorological data. This work was supported by JSPS KAKENHI Grant Number 15K08766.

About the Presenter

Masahiro Hosoda, Ph.D. is a lecturer at Hirosaki University in the Department of Radiation Science and specializes in radiation measurements. In 2007, Dr. Hosoda earned his Ph.D. in health sciences from Tokyo Metropolitan University of Health Sciences. Throughout his career he has been involved with radiation research at Chuoh College of Medical Technology,

the National Institute of Radiological Sciences, and Hirosaki University. In addition, he worked in the Office of Radiological Protection, Environmental Protection Agency, Ireland as a visiting researcher from April 2015 to March 2016. He is also a member of several local committees for environmental radiation monitoring. Dr. Hosoda has developed radon diffusion coefficient and exhalation rate measuring system. After the Fukushima nuclear accident, he developed new technique to evaluate the thyroid equivalent dose for the residents.

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Session Classification :   Radioactive Noble Gases

Track Classification :   Radioactive Noble Gases

Contribution ID : **93**   Type : **Poster**

Simulation of well type HPGe detector for samples both in the hole and on the top of the endcap

Wednesday, 28 September 2016 10:04 (0:02)

Content

High sensitivity of gamma ray spectrometry for a small amount of sample is advantage of a well type HPGe detector over a coaxial type one. Application of both small samples in the hole of the endcap of the detector and large samples on the top of the endcap extend usefulness in practical use. For the samples in the hole, correction factors of the self-absorption and the coincidence summing effect were previously estimated by numerical analysis and Monte Carlo simulation. Peculiar structure of germanium crystal and component object complex a model used in the Monte Carlo simulation especially for the samples on the top of the endcap. This study shows a model that was assembled on the bases of three types of calibration with a cross-sectional drawing supplied by the implementer. Simulation of the model was conducted using EGS5 code, and the results were compared with the calibrations. The model can be utilized for estimation of correction factors and uncertainties in the cases of both the hole and the top samples. The calibrations for a well type HPGe detector (GWL-150-50-S, ORTEC) were conducted by using 1) point sources at 25 cm from the top surface of the endcap, 2) 100 cm3 volume sources on the top of the endcap, and 3) 5 cm3 small volume sources in the hole of the endcap. Counting efficiencies of full energy peak were obtained from point sources between 60 keV from Am-241 and 1.8 MeV from Y-88. The efficiency characteristics to gamma ray energy were applied to determination of a sensitive area in the germanium crystal and the components which absorbed gamma rays at the place between the point source and the crystal. The crystal had a thick dead layer on the lateral side and the bottom. A 1.63 mm thick copper plate was placed between the endcap and the top surface of the crystal. In addition to these principal components for the energy characteristics, we assumed that additional dead area existed at the surface and outer edge of the crystal. As a result, calculated counting efficiencies agreed with the experimental efficiencies in 4 % in the whole gamma ray energy region. Counting efficiencies for the 100 cm3 on the top and 5 cm3 volume sources in the hole was obtained by calibration using Cs-134 and Cs-137 standard solutions. The model of germanium crystal created in the point source was applied to these volume source calibrations. The coincidence summing effect was considered in the simulation using the technique which was developed in previous study. A position of the crystal model in the endcap was adjusted by comparison of the counting efficiencies of the 100 cm3 source. A diameter of well at the center of the crystal was adjusted in 0.1 mm intervals from the calibration of the 5 cm3 source at last. The deviations between the calibration and the simulation were less than 5 % with variation in amount of the standard solution except for the Cs-134 sample in the hole. In this study, the model of well type germanium crystal which was applicable for estimating sensitivities of both the top and the hole samples was proposed. The comparison between the results of calibration and simulation indicated acceptable agreement for actual measurement. The results were demonstrated in the whole energy region of gamma ray spectrometry. Variation in sensitivity of any type of sample in material and volume can be complemented by simulation employing the model.

About the Presenter

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **94**   Type : **Oral Presentation**

Silicon PIN diode based electron-gamma coincidence detector system for Noble gases monitoring

Thursday, 29 September 2016 14:00 (0:20)

Content

Detection of the CTBT-relevant xenon isotopes (Xe-131m, Xe-133m, Xe-133 and Xe-135) in the International Monitoring System network and/or in the On-Site Inspection may provide the ultimate evidence (smoking-gun) for a potential clandestine nuclear explosion in violation of the nuclear test ban treaty. These isotopes are emitting low energy gamma and X-ray photons in coincidence with beta and conversion electrons. Therefore, electron-gamma coincidence detector systems are used for their measurement. Gamma detectors used in such systems are commonly NaI crystals, with some recent developments demonstrating use of HPGe. Plastic scintillators coupled to PMTs are currently used for the electron detection. Large area silicon PIN photodiodes (SiPIN) can be used as direct full energy deposition detectors as opposed to more traditional use for collection of light produced in the coupled scintillators. SiPIN based beta-gamma detectors are the most recent developments for the radioactive Noble Gas detection applications in the context of the CTBT monitoring. The SiPIN provide superior energy resolution for electrons (<10 keV at 129 keV electron energy, a factor of four improvement compared with the plastic scintillators) which allow a clear separation of the metastable radioxenon isotopes Xe-131m and Xe-133m (129 keV CE and 199 keV CE, respectively). These isotopes are key to the discrimination of the peaceful nuclear activities such as nuclear power plant emissions or medical isotope productions from nuclear explosions. The work describes the current state of technology development, preliminary results of the long-term performance studies with integration into some of the existing Noble Gas monitoring systems. The study of the operational aspects of the SiPIN based detector systems are key in the assessment of their suitability for the deployment at sometimes remote IMS locations as well as in the field applications for the On-Site inspection verification regime. We discuss the differences in the analysis and calibration algorithms as compared to the traditional plastic scintillator based detector systems. The individual SiPIN detectors are arranged in a cube with each side being an independent detector. This segmentation and the ability of SiPIN based system to record list mode data (events) provide further ways to reduce the background and interference between isotopes. We also present preliminary thoughts and assessment of sensitivity of the SiPIN detectors in a compact field-deployable system for Kr-85 measurement, with the possible applications for the detection of undeclared nuclear fuel reprocessing activities.

About the Presenter

Mr. Khrustalev holds a MSc degree in Physics from Syracuse University, NY, USA, specializing in the experimental High Energy Physics and development of detectors for ionizing radiation. He has been involved in the Noble Gas systems development and testing since more than 10 years. After his work at Austrian Research Centers GmbH, Seibersdorf, Austria, and at CTBTO PrePcom PTS, IMS/ED section, he is now working as Senior Engineer in Lares LLC, St.Petersburg, Russia, as well as an independent engineering consultant in the area of radionuclide monitoring.

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Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **95**   Type : **Oral Presentation**

A Novel Methodology for the Ultratrace Determination of Uranium and Thorium in Polymer Materials

Tuesday, 27 September 2016 09:20 (0:20)

Content

A quick and ultrasensitive dry ashing method was developed for determining the radiopurity, specifically the U and Th content, of a variety of polymer materials. Ultralow background polymers are needed in rare-event ultralow background physics experiments, *e.g.*, neutrino and dark matter studies, which require the effective screening of polymers for their inclusion in the detector. Historically, ultrasensitive assay required gamma counting kilogram-quantities of material on the world's most sensitive detectors for several months in order to determine the radiopurity of the materials to the levels necessary (*e.g.*, microBq/kg or pg/g). A quicker and more sensitive method was developed by employing a dry ashing technique using a quartz tube furnace with offline detection by inductively coupled plasma mass spectrometry (ICP-MS). Ratiometric methods utilizing non-natural Th-229 and U-233 tracer spikes were used for quantitation. As many types of commercially-available crucibles (*e.g.*, quartz, sapphire) can be problematic due to highly variable contributing backgrounds and/or poor recoveries, electroformed copper crucibles that were grown and constructed in-lab were used for ashing the polymers cleanly and most effectively. After ashing, the entire crucible and ash residue was digested in nitric acid. The copper matrix was removed from the analytes via anion exchange column separation before analysis by ICP-MS. Electroformed copper crucibles provided minimal background contribution and allowed for sub-ppt (*i.e.*, low microBq/kg) detection limits using small sample quantities (*ca.* 100 mg). Subsets of process blanks and samples were either spiked with tracer before or after ashing to test the effect of ashing on tracer recovery; recoveries were high and consistent across sample subsets. This new method allows for the ashing of *ca.* 30 samples per ashing cycle, and can be processed in a matter of days. Results for a variety of polymers will be discussed.

About the Presenter

Isaac Arnquist is currently a postdoc analytical chemist at Pacific Northwest National Laboratory focusing on ultralow background materials assay, primarily using ICP-MS. He enjoys long forays in the cleanroom and decadent double beta (hold the neutrinos) with a slice of dark matter.

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Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **96**   Type : **Oral Presentation**

Development of a Low-Level 39Ar Calibration Standard – Analysis by Absolute Gas Counting Measurements Augmented with Simulation

Friday, 30 September 2016 09:40 (0:20)

Content

Argon-39 is an attractive environmental radiotracer for monitoring phenomena related to ground-water transport. With a half-life of 269 years, 39Ar provides continuity and overlap with other more commonly used radiotracers such as 3H and 14C. The age of a water sample is determined by comparing the 39Ar specific activity of the gas separated from ground-water with equilibrium 39Ar atmospheric levels (1.01 Bq/kg-ArNAT or 1.80E-6 Bq/cc-ArSTP). Such measurements require the use of low-level gas counting techniques which have been calibrated using well characterized 39Ar standards. This paper describes the generation of 39Ar, via reactor irritation of potassium carbonate, followed by quantitative analysis, based on length-compensated proportional counting, to yield standards that are approximately 60 and 3 times atmospheric background levels of 39Ar. Multiple measurements of the 60x standard, at various pressures, were performed in Pacific Northwest National Laboratory's shallow underground counting laboratory in order to study the effect of gas density on beta-transport within the counters. In order to estimate the specific activity of the standard from measurements based on length-compensated proportional counting it is necessary to account for disintegrations that do not deposit sufficient energy in the counter to register above threshold. These losses are commonly referred to as the so-called Wall-Effect (betas reaching the wall before depositing sufficient energy for detection) and Threshold-Effect (total deposited energy below detection threshold). For this study both the Wall- and Threshold-Effect have been estimated using Monte-Carlo simulations and applied to the experimental measurements. An uncertainty model of the measurements and data analysis has been developed in accordance to the Guide to the Expression of Uncertainty in Measurements (GUM). The most challenging source of uncertainty to quantify is that from the Monte-Carlo simulations. The total expanded uncertainty (K=2) result for the 60x-background 39Ar standard, less any uncertainty contribution from the Monte-Carlo simulation, is 1.3% (approximately 95% confidence). Efforts to estimate the magnitude of the uncertainty from the simulation are discussed along with future directions for improved simulations.

About the Presenter

Dr. Richard Williams is a Senior Research Scientist at Pacific Northwest National Laboratory (PNNL) where he has worked since 1997 after receiving his PhD in Physical Chemistry from the University of Colorado at Boulder, CO. He is currently in the Detection Systems Technical Group within the Signature Science and Technology Division at PNNL. His technical experience includes many areas of sensitive or low-level measurements; including trace chemical detection and low-level radiological studies. In addition, he has contributed to multiple projects by developing uncertainty models following the ISO GUM standards.

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Session Classification : Quality

Track Classification : Quality

Contribution ID : **97**   Type : **Poster**

Proficiency testing for measurement quality control of gamma ray spectrometry using brown rice.

Friday, 30 September 2016 10:02 (0:02)

Content

Many laboratories measure radioactivity of Cs-134 and Cs-137 after the accident at Fukushima. It is effective for providing reliable results of measurement to grasp own measurement capability and improve it if any problem emerged through proficiency testing. In this study, to find out problems about the measurement and obtain the information which can be utilized for quality control, we carried out the proficiency testing. In the proficiency testing, we calculated the En value as an indication for laboratories which may have problem with their measurement. The signal in the En value is caused by (1) large difference between the reported and the reference value and (2) underestimation of uncertainty. We checked them at every report from the signaled laboratories. The proficiency testing was held in January 2015, and 145 laboratories reported 176 measurement results with their uncertainties. To find out problems of the measurement, we asked participants to report their measurement condition such as the sample density and correction factors. We showed participants how to estimate dominant uncertainties before the proficiency testing. The sample was brown rice harvested in Fukushima in 2011. We mixed and homogenized the samples adequately and filled them every 100 g in a bag to send. We filled 22 containers with the samples, and determined reference values by an HPGe detector. The reference values were obtained as 17.8±0.8 Bq kg-1 and 57.8±2.8 Bq kg-1 (k=2) for Cs-134 and Cs-137, respectively. The number of reports whose absolute value of the En value was bigger than 1 was 25 for Cs-134 or Cs-137 (Labtotal). 14 reports were signaled only for Cs-134 (Labcs-134), 6 were only for Cs-137(Labcs-137), and 5 for both nuclide (Labboth). Firstly, we reviewed the reported values in point of difference between the reported and the reference value. We checked whether Labtotal had biases on correction factors against other reports which were derived from a near degree of relative efficiency HPGe detector. Correction factors about the coincidence summing effect from Labcs-134 were normal against other reports. The self-absorption correction factors were also normal in the Labtotal. Evaluation procedure of these factors was declared on the domestic official guides in Japan. These results show that the evaluation of the correction factors leads to accurate analysis of radioactivity. Among Labboth, 3 laboratories reported their density filled in the container as bigger than 1 g cm-3. The filling density of grains such as brown rice seems to be about 0.9 g cm-3 in usual. We asked these laboratories to revise the density. As a result, the En values of 2 laboratories were improved. The results show that there were careless mistakes about evaluation of the mass quantity. Secondary, we reviewed the reported values in point of uncertainty. 5 reports among Labtotal, estimated smaller uncertainties than the sum of squares of itemized uncertainties. The En value of 2 of them would become less than 1 if their uncertainties were combined accurately. Uncertainties of 2 reports among Labtotal about statistics were obviously smaller than presumed from measurement time. An uncertainty about the calibration value was underestimated in 1 report among Labtotal. Uncertainties of 3 reports among Labtotal which reported no itemized uncertainties were obviously too small against other reports. These examples show that the skill to evaluate uncertainties should be improved. We found out issues to improve the measurement procedure and obtain

the valuable information which can be utilized for the quality control from the result of the proficiency testing.

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Session Classification :   Quality

Track Classification :   Quality

Contribution ID : **98**   Type : **Poster**

A detector for radionuclide monitoring in water systems

Tuesday, 27 September 2016 15:00 (0:02)

Content

Drinking water systems are vulnerable to contamination with radioactive material, either by accident or on purpose. Methods applied in routine monitoring of water systems (like regular sampling with subsequent laboratory analysis) cannot detect short time contaminations and can therefore not prevent a resulting radiation exposure of the population. For that purpose, based on a scintillation detector, a real-time measurement system is being developed that can detect alpha, beta, and gamma radiation with an automatic analysis and warning algorithm. The problem in detecting alpha, beta, and gamma radiation at the same time lies in their different range in matter. Gamma radiation can as well be measured outside of a water volume, short-ranged alpha and low-energy beta radiation can only be detected in direct contact to the medium. On the one hand low detection limits for alpha-emitting radionuclides can thus only be achieved by detectors with large surface areas. On the other hand for the higher energy beta and gamma emitters large detection volumes are required. Since the dimensions of the detector are limited, the detection geometry needs to be a compromise. To achieve a high sensitivity for all kinds of radionuclides, simulations with the GEANT4 based GAMOS Monte Carlo system were performed in order to optimize the detection geometry, e.g. enlarging the surface area (that is needed for alpha and beta detection) while at the same time retaining a sufficiently good light transport to the photosensor. The models used for the simulations have been validated using measurements of simple detection geometries. Based on the results of several simulations, which systematically varied different geometric parameters, a compromise was made between the different parameters. The final prototype consists of plastic scintillator cast sheets that are coupled to a photomultiplier, the housing has been adapted to the components via 3D printing. Water which is to be measured can flow between the sheets. With this setup, the surface area and therefore the sensitive volume for short range radiation can be greatly enhanced compared to scintillators solely on the outer surface of the medium, thus resulting in a higher sensitivity and lower detection limits. A software with a graphical user interface was developed to perform measurements with the detector. It allows the user to monitor the activity concentration over time as well as the spectra of the individual measurements. After an optimization of the PMT- and MCA-parameters (voltage, internal amplification, . . .), for Co-60, the first prototype with an effective volume of 300 ml achieves a lower limit of detection (LOD) of 0,07 kBq/l for a measuring time of 10 minutes while for Am-241 it is 2 kBq/l. These detection limits were accomplished using only the integral count rate without any further spectrum analysis. It is expected that these will be lowered when more sophisticated analysis of the spectra are performed. Based on these promising results of the lamellar structure a new prototype is being developed with a further increase in the surface area of one order of magnitude to lower the detection limit especially for alpha radiation.

About the Presenter

Jorrit Drinhaus is a PhD student at Karlsruhe Institute of Technology (KIT) in the department Safety and Environment. He studied physics at the University of Bonn where his

diploma thesis dealt with the upgrade of an electromagnetic calorimeter.

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Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **99**   Type : **Poster**

Measurement of radon exhalation rate in NORM used as consumer products

Friday, 30 September 2016 15:10 (0:02)

Content

Materials containing a significant amount of natural radionuclides are referred to as Naturally Occurring Radioactive Material (NORM). The necessity of regulations that control human exposure to NORM was pointed out in the International Commission of Radiological Protection Publication 60 (ICRP, 1991). In Japan, a guideline for control of materials containing uranium and thorium was published by the Ministry of Education Culture, Sports, Science and Technology in 2009. Recently, consumer products such as clothes, water purification reagent, wristband, bedrock bath instruments and hot spring instruments that contain natural radionuclides have predominantly been commercially available in Japan. Although the activity concentration of natural radionuclides such as U-238, Ra-226, Ra-228, K-40 in these consumer products and dose estimation of users handling them has been reported in the past, radiological information on their radon exhalation is rare. In this study, consumer products, such as clothes, water purification reagent, wristband, bedrock bath instruments and hot spring instruments containing natural radionuclides, currently distributed in Japan were collected, and radiological characterization on the radon exhalation was carried out. Determination of the radon exhalation rates in the samples was carried out using the can technique. The passive detector with CR-39 was fixed at the top and center of a chamber. The samples were placed at the bottom and center of the chamber. The chambers were sealed and stored for 1 month. After the 1 month, the detectors were taken out, etched, and counted for alpha tracks. The radon mass exhalation rates were calculated from the alpha tracks, chamber volume, exposure time and sample mass. We will present the metrological results on radon exhalation rates in consumer products including NORM.

About the Presenter

Kazuki Iwaoka, Ph.D. is an assistant professor at Hirosaki University in the Department of Radiation Physics and specializes in radiation measurements. In 2010, Dr. Iwaoka earned his Ph.D. in sciences from Chiba University. Throughout his career he has been involved with radiation research at the National Institute of Radiological Sciences, Ministry of Health labor and Welfare in Japan, and Hirosaki University. Dr. Iwaoka has developed continuous radon bronchial dosimeter. He is currently working on dose estimation of general public handling NORM and regulatory science about limits for food contaminated with radionuclides.

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Session Classification :   Special Session: Metrology of NORM

Track Classification :   Special Topic: Metrology of NORM

Contribution ID : **100**   Type : **Oral Presentation**

ICP MS measurements of ultra low-level radioactivity in solid material and comparison with γ-spectrometry within the CUPID experiment

Monday, 26 September 2016 14:00 (0:20)

Content

CUPID (ArXiv:1504.03612v1) is a proposed future ton-scale bolometric 0νDBD experiment that will be built on the experience gained in CUORE and LUCIFER, both currently installed underground at the Gran Sasso Laboratory in Italy. CUPID eventually aims at a sensitivity for the effective Majorana neutrino mass on the order of 10 meV, covering entirely the inverted hierarchy region of the neutrino mass pattern. This ambitious objective poses a set of very demanding technical challenges, among them a strong reduction of the background, which could allow in the best case to have no background event in the region of interest for the whole lifetime of the experiment. Common sources of background include cosmic rays, the environmental radioactivity surrounding the detector and radioactive contaminations naturally present in the materials used to build the detector itself. The operation of the experiment in the underground laboratory and the use of suitable shielding around the detector will suppress the cosmic ray flux and the environmental radioactivity. A strict selection of ultra-pure materials is fundamental for the construction of the experiment. Extremely sensitive analytical techniques, such as alpha and gamma spectroscopy, neutron activation analysis (NAA) and inductively coupled plasma mass spectrometry (ICP MS) are used for the selection of sufficiently radiopure materials. However, the actual detection limits for naturally occurring radio-contaminants achievable with these analytical techniques often translate into potentially dangerous count rates for the CUPID experiment. For this reason, an improvement of the currently attained sensitivities is mandatory for the selection of materials to be used in CUPID. Pre-concentration techniques typically allow an increase of the sensitivities, especially when coupled with analytical techniques such as mass spectrometry. In this work, ICP MS measurements of the long-lived radio-nuclides Th and U at ultra-trace levels in copper, which is envisaged to be one of the CUPID detector materials, are presented. A dedicated study has been carried out in order to develop an analytical procedure able to maximize the sensitivity for the quantification of Th and U in that matrix. The chemical separation and pre-concentration of the analytes was performed using chromatographic extraction techniques. Different resins have been explored. Best efficiency and lowest background were obtained with two of these resins, which allowed to reach detection limits of the order of 10^{-13} g g-1. Together with pre-concentration of the analytes, also a reduction of the instrumental background was needed to further improve detection limits. For this purpose, a careful cleaning of all the vials involved in the sample preparation procedure and a preliminary rinsing of the resins themselves were performed. Ultra-pure grade reagents were used and all operations were carried out in an ISO6 class cleanroom. The obtained results, which represent a significant goal in the measurement of trace elements in solid materials, are reported in this work. Moreover, the ICP MS technique allowed a depth profile contamination study of the copper samples using selective and controlled dissolution steps of the copper samples.

About the Presenter

I am currently a postdoc at the INFN-Gran Sasso National Laboratory in Italy. I have a Master Degree in Chemistry, obtained with honors at the University of L'Aquila (Italy) in 2010, and a Ph.D. in Physics, successfully completed in March 2016 at the University of L'Aquila (Italy). I have a solid experience in isotope and trace element mass spectrometric analysis, including analyses on a quadrupole ICP-MS, high resolution ICP-MS and TIMS. My work mainly focuses on the detection of low-level radioactivity through the measurement of long-lived radionuclide traces in several samples types and on the development of new analytical methods for the improvement of detection limits. In 2012 I have been working as a guest research collaborator at the Chemistry Department of the Brookhaven National Laboratory. I am co-author of several published papers on international scientific journals and I attended several international conferences on mass spectrometry and radio-analytical chemistry.

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Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **101**   Type : **Poster**

A low-energy set-up for gamma-ray spectrometry of NORM tailored to the needs of a secondary smelting facility

Friday, 30 September 2016 15:06 (0:02)

Content

In the context of striving for a sustainable society, residues are increasingly used as input-material for certain industries. Many metals can for example be extracted and recycled in this way. In the frame of the European project "MetroNORM" (Metrology for processing materials with high natural radioactivity) several European NMIs (National Metrological Institutes) have worked together to develop new radiological methods adopted for measuring NORM (Naturally Occurring Radioactive Materials) and to produce reference materials suitable for testing these new methods. One work package in this projects deals with in-situ measurements at industries. Five companies in different industrial branches were selected and specially designed measurement stations were developed and installed on-site. This paper deals with a gamma-ray spectrometry measurement station developed for a secondary smelter for metal production using input from industries with NORM as indicated in Annex VI of the Euratom Basic safety standards (EU-BSS, Council Directive 2013/59/EURATOM). The main radiological interest for the MetroNORM part for this project is the study of 210Pb and 210Po but all the primordial radionuclides that can be detected using gamma-ray spectrometry should be monitored. The set-up and the associated software were designed in such a way as to enable adequate and relatively rapid monitoring of incoming material (mainly slag) and final products. The main aim was to check that incoming material was below clearance levels, which required relatively short measurement time for 210Pb but long measurement time for 210Po. It was, however, also important to quantify all gamma-ray emitting natural radionuclides as well as lower activity levels to better understand the processes involved in the production and to link activity in the output to the input and process. This will eventually be used to better control and steer processes in a more efficient way. The measurement station was based on a low-background point-contact HPGe-detector with a sub-micrometre top deadlayer (a Canberra BEGe detector, BE2825). It was installed in a low-background lead/copper shield inside the chemistry laboratory of the company. A special feature of the set-up was that the signal was split in two parts so that two spectra were collected using two chains of digital electronics. One chain had high amplification to obtain sufficient number of channels in the low-energy peaks and the other chain had low amplification to be suitable for the high energy peaks. The sample preparation for slag involved crushing, sieving and usage of plastic sample containers of 186 mL. The sample from the final product was a cylindrical slab of metal that was just rinsed on the outside with iso-propanol. The main aim was simultaneous determination of 210Pb using the 46.5 keV gamma-ray and 210Po using the very weak 803 keV transition, which was also possible but only in the samples of the final products as they were depleted in 40K and the Th and U decay chains. To reach a detection limit of 5 Bq/g, the standard measurement time was 15 minutes but detection of 210Po required a 12 hour measurement due to the extremely low emission probability of the 803 keV line (0.00123%). An important step for obtaining low-detection limits for given radionuclides was during sieving as different radionuclides accumulated in different parts (size-fractions) of certain slag materials. The paper will

describe the measurement set-up and the main steps in the measurement sequence to obtain low detection limits for the most important radionuclides.

About the Presenter

Mikael Hult has been the ICRM-LLRMT WG coordinator since 2012. He is specialised in underground gamma-ray spectrometry and has led the collaboration CELLAR (Collaboration of European Low-level underground Laboratories). He is the author of more than 100 scientific articles in the field of applied nuclear physics. He is head of the Radionuclide Metrology Sector of the European Commission's JRC-Geel in Belgium.

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Session Classification :   Special Session: Metrology of NORM

Track Classification :   Special Topic: Metrology of NORM

Contribution ID : **102**   Type : **Poster**

Combination of automated chromatographic separation and off-line Cherenkov counting in determination of low level activity of Sr-90.

Thursday, 29 September 2016 10:02 (0:02)

Content

Radiostrontium as an high yield fission product with long physical (28.75 years) and biological half-life (˜12 years), is one of the most hazardous radiocontaminants in the environment. Therefore, almost all environmental radioactivity monitoring programs include its quantitative determination. Due to its radiochemical properties standard procedure for its determination is complicated and time consuming. In recent years fully automated approach for monitoring pure beta emitters has been developed. However, there is a lack of prompt and reliable methods for determination of low-level activities in environmental samples. In our laboratory semi-automated procedure for determination of 89,90Sr in liquid waste was established. Procedure includes separation of strontium from matrix on Super Lig 620 column followed by off line on column detection via Cherenkov counting on commercially available instrument. The goal is further development of mentioned method for monitoring environmental occurrence of 90Sr and determination of low level actvity of 90Sr by Cherenkov detection. Therefore, in this paper procedure for determination of low level activity of Sr-90 which includes separation of strontium from matrix on chromatgraphic column followed by off line on column detection via Cherenkov counting will be presented. This includes simultaneous selective binding of 90Sr and 90Y on chromatographic column filed with mixture of DGA-SuperLig 620 resins and subsequent on column Cherenkov detection. With assumption that 90Sr is in equilibrium with its daughter 90Y in sample, mixture of SuperLig 620 and DGA resin might enable rapid selective separation of 90Sr and 90Y from matrices and direct on column Cherenkov counting. Therefore, method consist of automated sample delivery to the column filled with DGA/SuperLig resins and 90Sr-90Y Cherenkov counting on low level counter, TriCarb 3180 TR/SL. Sample is delivered to the column at constant flow rate until the breakthrough point and 90Sr via 90Y was determined by counting column in PE vial surrounded with HNO3 to achieve best efficiency determination. Thereby, to develop this method, best mixing options using different media were examined as well as breakthrough curves for strontium and yttrium in 0.5M HNO3 were determined. As quantitative determination requires accurate and precise determination of the detection efficiency it will be shown how Cherenkov counting efficiency depends on type of media, volume, color, presence of gamma emitters etc., and how detection limit can be improved by optimization of these parameters.

About the Presenter

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Session Classification :   Radiochemical Techniques

Track Classification :   Radiochemical Techniques

Contribution ID : **103**   Type : **Oral Presentation**

Advancements in NORM metrology – Results and impact of the European joint research project MetroNORM

Friday, 30 September 2016 14:20 (0:20)

Content

Naturally occurring radionuclides are present in many natural resources. Industrial activities that exploit these resources may lead to enhanced potential for exposure to Naturally Occurring Radioactive Materials (NORM) in products, by-products, residues and wastes. Traceable, accurate, and standardised measurement methods and instruments, in particular for in-situ applications, are needed to decide on the re-use of waste materials without increasing costs whilst avoiding contamination of the environment and exposure of the public. Ionising radiation measurement in the recycling industry currently focuses on artificial radionuclides.

In this paper the main scientific results of the three years European Metrology Research Programme joint research project MetroNORM - Metrology for processing materials with high natural radioactivity – are presented. Significant improvements have been achieved by development, design and successful test of a novel hand-held prototype in-situ gamma-ray measurement system, an in-situ alpha-particle spectrometry prototype by integration with a remote expert support systems, a measurement system based on pixel detectors (MEDIPIX/TIMEPIX) and final sample preparation stage for the selected NORM measurement techniques. For 220Rn, the production chain in a vacuum chamber has been designed and the set-up and the generators and samples together with the chamber have been constructed and tested successfully. NORM standard reference materials and sources for calibration of laboratory instruments and in-situ measurement instruments - covering the NORM radionuclides 238U, 235U, 226Ra, 210Pb, 228Ra, 228Th, 208Tl, 228Ac, 214Bi, 214Pb, and 40K - have been prepared and applied successfully. In total 10 calibration and reference standards for gamma-ray spectrometry and alpha spectrometry measurement and reference materials for in-situ measurement systems have been developed. The laboratory and in-situ measurement systems and procedures for the measurement of NORM radionuclides and the reference materials have been developed with total relative measurement uncertainties lower than 10 % (k=1).

The revision of nuclear decay data of natural radionuclides has been carried out in order to improve NORM radionuclide metrology so that as many as possible descendants of uranium and thorium decay chains can be sufficiently accurately measured. To improve the required NORM related decay data, special radionuclide sources with the radionuclides 235U, 227Ac, 226Ra and 210Pb and had been carefully prepared and tested. A revised decay scheme for 138La including updated decay data has been established. In addition, the complex gamma-ray spectra of selected NORM key-materials have been measured and evaluated.

The potential impact of the results on NORM industrial practices by implementing the developed laboratory and in-situ measurement methods, procedures, instruments and reference materials is discussed. The scientific output of the joint research project have been so far – and potentially will be in future – considered in European and national standard bodies' working groups on dose assessment and classifications of emitted gamma radiation for building materials, technical preventive radon measures for buildings and the determination and evaluation of the total dose due to radionuclides at drinking water production plants.

This joint research project, contract identifier EMRP/IND57, has been done in the frame of the European Metrology Research Programme EMRP, which is jointly funded by the EMRP participating countries within EURAMET and the European Union.

About the Presenter

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Contribution ID : **104**   Type : **Oral Presentation**

Long-term environmental radioactive contamination of Europe due to the Chernobyl accident - Results of the ICPDR Joint Danube Survey 2013 radioactivity measurements

Tuesday, 27 September 2016 14:40 (0:20)

Content

This paper was carried out within the scope of the Joint Danube Survey 3 (JDS3), co-ordinated by the International Commission for the Protection of the Danube River (ICPDR) was the world's biggest river research expedition of its kind in 2013, the UN International Year of Water Cooperation. A Joint Danube Survey is carried out only once every six years – JDS1 was held in 2001 and JDS2 in 2007. JDS3 completed the sampling in 2013 to enter an extensive ecological, biological, chemical and radiometrical analysis stage [1]. The Joint Danube Survey pursued three main objectives: 1) To collect information on parameters not covered in the ongoing monitoring, 2) to have data that is readily comparable for the entire river because it comes from a single source and 3) to promote the work of the ICPDR and raise awareness for water management. Carrying out JDS3, for six weeks between 13 August and 26 September 2013, the JDS3 ships travel 2375 km downstream the Danube River, through 10 countries, to the Danube Delta. An international Core Team of 20 scientists was responsible for sampling, sample processing, on-board analyses and all survey activities. 68 sites were sampled by the JDS3 Core Team along a 2581 km stretch of the Danube, 15 of which were located in the mouths of tributaries or side arms. Samples from the first two stations in Germany were collected using cars, the remaining 2354 km were sampled by ships.

The specific activities of artificial and natural gamma-ray emitting radionuclides and β-particle mitting 90Sr in bottom sediment samples from the 68 locations along the Danube river were determined by gamma-ray spectrometry and radiochemical analysis. The bottom sediment samples were taken from the left and right banks of the Danube river by surface bottom sediment sampling with 1-1.5 m water depth with a sampling net. This was followed by on-board homogenisation and grain size fractioning with wet sieving in order to get the less than 63 μm grain size fraction for radiometrical analysis in the laboratory. Before analysis, the sediment samples had been dried in the laboratory at 105 °C. All results are given for dried samples (< 63 μm fraction, 105 °C). The yield of strontium extracted from the geological matrix was determined by total reflection X-ray fluorescence (TXRF). The 90Sr was then processed radiochemically, separated with strontium-selective resins and quantified by liquid scintillation counting (LSC).

27 years after the environmental contamination due to the Chernobyl accident the 90Sr contamination level of the Danube bottom sediment is low and did not exceed 10 Bq/kg with a few exceptions. 137Cs and 40K have been radiometrically analysed by low-level gamma-ray spectrometry in the Low-Level Counting Laboratory Arsenal, Vienna. Generally the 137Cs activity concentrations of the bottom sediment are below 100 Bq/kg. A significant decrease in specific activity in sediment along the river was observed.

This set of observations is of great importance since it is the first one of this type of radiometrical analysis done for the whole Danube river. The radiometrical results of the JDS3 survey have not been published so far.

[1] ICPDR, JDS3 Final Scientific Report, Joint Danube Survey 3. A Comprehensive Analysis of Danube Water Quality. ISBN: 978-3-200-03795-3, Vienna, 2015.

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Track Classification :   Applications

Contribution ID : **105**   Type : **Oral Presentation**

Analysis of radionuclides at ultra low levels: synergy of low and high-energy mass spectrometry with gamma-spectrometry

Monday, 26 September 2016 13:40 (0:20)

Content

Recent developments in low-energy (mainly associated with ICPMS – Inductively Coupled Plasma Mass Spectrometry) and high-energy mass spectrometry (represented by AMS – Accelerator Mass Spectrometry) have made them dominant techniques for analysis of long-lived radioisotopes (e.g. 10Be, 14C, 36Cl, 41Ca, 53Mn, 99Tc, 129I, 135Cs, uranium and plutonium isotopes) in various types of samples from meteorites to deep ocean seawater. In the radiometrics sector the most important development has been associated with underground operation of large volume Ge detectors, which have been dominating in analysis of short and medium-lived radionuclides emitting gamma-rays (e.g. 7Be, 54Mn, 60Co, 134Cs, 137Cs, 210Pb). This has been mainly because of better sensitivity (a higher detector efficiency and a lower background), which helped to decrease a sample size at least by about a factor of ten, and improve thus the detection limits down to μBq/kg, by about three orders of magnitude when compared with previous installations. Specific attention has been given to Monte Carlo simulations of background characteristics of Ge detectors, which if carried out in advance of the construction of a low-level spectrometry system, they could predict its characteristics and parameters. New developments in ultra low-level radionuclide analysis have had great impact on nuclear science and applications in environmental, life and space sciences. Many of the applications were not possible to carry out before either because of a lack of suitable samples (as too large samples were required for radionuclide analyses), or because of limited analytical sensitivities of existing instruments. Specific features of radiometric and mass spectrometry techniques for analysis of radionuclides in the environment at ultra low levels will be compared, and applications of radionuclides as tracers of environmental processes recently carried out by the University of Bratislava in collaboration with other laboratories will be presented.

About the Presenter

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Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **106**   Type : **Poster**

Monte Carlo simulations of background characteristics of Ge detectors operating in the Gran Sasso underground laboratory

Wednesday, 28 September 2016 14:40 (0:02)

Content

If a low-background Ge spectrometer would be constructed from selected radioactivity-free materials, the dominating background component in surface or shallow underground laboratories should be due to cosmic rays. This is due to the fact that the flux of soft component cosmic-ray particles (electrons, positrons, gamma-rays) can be considerably decreased by their absorption in materials with high atomic number, e.g. lead, iron or copper. On the other hand, the flux of hard component cosmic-ray particles (muons) can be decreased only by installation of detectors deep underground, or a partial decrease can be achieved by installation of an anticosmic shielding. The typical background of Ge detectors is consisting therefore of cosmic-ray induced component, a radioactive contamination of construction parts of the detector and a contamination of materials found in the laboratory. It has been expected therefore, that in a deep underground laboratory (a several thousands of meters of water equivalent, w.e.), the influence of cosmic rays on the detector background should be negligible, and the dominating component would be a radioactive contamination of construction materials. The aim of our work has been a developing of a computing code that would allow an evaluation of background components of low-level Ge gamma-spectrometers, even in the designing stage, before their construction and installation in a deep underground laboratory. The simulation code is based on the GEANT 4 package developed at CERN. The idea was then to compare background gamma-ray spectra measured in a deep underground laboratory with predicted ones obtained from Monte Carlo simulations. Monte Carlo simulations of background components of low-level Ge gamma-ray spectrometers operating in a deep (about 1400 m of rock, providing about 3400 m w.e.) Gran Sasso underground laboratory was carried out. The experimental results showed that the total background of the HPGe detectors has been by about two orders of magnitude higher than the Monte Carlo predictions when only cosmic-ray induced background has been included in the comparison. The higher measured background should be due to radioactive contamination of the construction parts surrounding the Ge crystal, as well as due to presence of radon and its decay products in the laboratory. The contamination levels of the primordial radionuclides surrounding the Ge detector were required to be set in the Monte Carlo model at 1 mBq/kg for 40K, 0.1 mBq/kg for 232Th and 0.1 mBq/kg for 238U to get an agreement with the measured gamma-ray spectra.

About the Presenter

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **107**   Type : **Poster**

Radiocarbon concentration in the atmosphere and in tree rings in the south-west Slovakia

Monday, 26 September 2016 16:52 (0:02)

Content

The 14C tree-ring record is well averaging method for estimation of the atmospheric 14C concentrations in CO2, documenting its suitability for long-term monitoring of 14C levels around Nuclear Power Plants (NPP). The increment borer for tree-ring sampling allows develop a long-term 14C record from the same tree. As the tree-ring samples are collected from living trees there is much bigger choice of trees around a NPP, so microclimatic conditions can be better taken into account (e.g., a wind rose). The Accelerator Mass Spectrometry (AMS) technology with miniaturization of samples below mg mass allows to analyze single tree rings with high precision so local 14C contributions from NPPs can be evaluated. Tree-ring samples offer a good possibility to reconstruct 14C concentrations in a given locality, usually back in time for several decades. The time resolution is limited by 1 year growing cycle of the tree, when some information on short-term variations in carbon isotopic composition could be lost (e.g., Suess minima or sudden 14C releases from NPP during winter). Atmospheric radiocarbon has been monitored in the Bratislava since 1967 and around the Jaslovske Bohunice NPP (Žlkovce station) since 1969. The aim of this paper has been to compare atmospheric radiocarbon data in Bratislava and in Žlkovce with tree ring data collected in Bratislava, Žlkovce and Vysoká pri Morave (a clean air station). In 2012, tree ring samples were collected from Tilia cordata using an increment borer at Žlkovce monitoring station situated close to the Jaslovské Bohunice NPP. Tree ring samples were also collected in 2014 at the Vysoká pri Morave clean air station. The aim of this study has been to investigate changes in radiocarbon concentration in the atmosphere and biosphere over the time period from 1970 to 2015. Each tree ring was identified and graphite targets were produced for 14C analysis by accelerator mass spectrometry (AMS). A gradual decrease from the bomb peak was observed in the measured radiocarbon concentrations, which was described by an exponential function. Influence of carbon dioxide released by fossil fuel combustion (Suess effect) can also be seen in all the stations, and potential local and regional carbon dioxide emission sources will be discussed. Radiocarbon concentration in tree-ring samples from Vysoká pri Morave shows an expected exponential decrease with time decay constant of (14.5 ± 1.2) years. Measured $\Delta 14C$ values are systematically lower than the clean air reference levels as a consequence of dilution by fossil CO2 depleted in radiocarbon (local Suess effect). The 14C concentrations obtained from the tree-ring samples have been in a reasonable agreement with the averaged annual 14C concentrations in atmospheric CO2.

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Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **108**   Type : **Poster**

A Second-generation Low-Background Gamma-Ray Spectrometer

Wednesday, 28 September 2016 14:42 (0:02)

Content

For the ultimate sensitivity in trace radiochemical analysis, the radiation detector must have high efficiency and low background. A well-characterized low-background Ge gamma spectrometer that has been in regular use at NIST since 1990 is being supplemented by a new system, improved in several ways. The relative efficiency of the new Ge detector is nearly three times that of the older system, which alone improves the detection limit substantially. Because the detection limit scales approximately as efficiency divided by the square root of background, the most cost-effective way of improving sensitivity is by buying germanium; a second benefit of a larger detector is improved peak/Compton ratio. Inside any good above-ground shield, the background counting rate is dominated by a continuum of high-energy cosmic-ray muons. This component can be nearly eliminated with an anticoincidence shield. An existing system in our laboratory reduces the continuum by a factor of 15 by closely surrounding the Ge detector with a NaI scintillator. With this arrangement the detection limit for 137Cs is improved by the expected factor of four, but in fact worsened by a factor of two for the cascade decay of 60Co; in addition, the geometry of this system limits the maximum size of the counting sample. In the new system, muons are vetoed by operating in anticoincidence with an umbrella of plastic scintillators covering three adjacent sides of the shield, so that any linear path through the detector must also traverse a scintillator. Muons also contribute to background by creating fast neutrons in the shield, giving characteristic (n,n′) excitation gammas from the shield material and the detector itself. Because the production rate of (μ,n) neutrons per kilogram of shielding is proportional to the atomic mass A, the new shield is constructed of 15 cm of pre-1945 iron rather than lead, thus reducing the fast-neutron flux to a fifth of that in the older lead shield. Its volume is large, to accommodate bulky or irregular samples that our laboratory occasionally needs to survey. The cryostat extends outside the shield to the preamplifier and Dewar though a stepped aperture that was cut by abrasive-jet machining. Both the Ge detector and the scintillators are operated by modern digital spectrometers, the speed of which gives acceptable system dead time from the large scintillation umbrella, and offers time-stamped event-by-event data acquisition.

About the Presenter

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **109**   Type : **Oral Presentation**

Mazinger, a gamma-ray spectrometry system of high efficiency and very low background for paloeoclimate applications

Tuesday, 27 September 2016 15:50 (0:20)

Content

The study of changes in climate on the scale of the entire history of Earth requires absolute dating methods that cover the total time period. 230Th and 234U disequilibria, as well as 231Pa and 235U, have shown as good candidates to provide ages older than 50000 y. Therefore, they are the basis for a method that allow to extend the 14C dating up to 500000 y. The variety of samples, their high number and the fact that several radionuclides are needed to obtain samples' chronology make gamma spectrometry to be a suitable technique in this task. However, its low efficiency and high background, therefore, high detection limits in comparison with alfa spectrometry need to be improved to become a real alternative in samples with very low activity levels. With this purpose, Mazinger, a new spectrometry system based on two HPGe detectors, which are surrounded by active and passive shieldings and placed 12 m underground, has been set up in the Ionizing Radiation Laboratory of the University of Salamanca. In this work, the Mazinger's performance is studied at the full energy range useful for natural radionuclides. In composite detectors, energy resolution is a consequence of the electronics adjustments, which need to allow for summing the raw spectra. Therefore, the method used to set up electronics and add spectra is described. Detector background is also analysed and compared with the one of a single low background HPGe detector as a function of the different shielding elements, obtaining gross values of order 10-4 cps. Efficiency and limits of detection are obtained for the main natural radionuclides in marine sediments belonging to the Mediterranean MD99438 core. Special focus is made on the 230Th determination whose results are compared with the ones provided by alfa spectrometry. Results show that limits of detection are reduced in an order of magnitude with respect to a conventional low-level background HPGe detector, being comparable to the corresponding ones to alfa spectrometry and doing Mazinger a first class in radiometry of natural radionuclides.

About the Presenter

B. Quintana works in gamma-ray spectrometry since the beginning of her academic career. Currently, she is associate professor of Nuclear Physics in the University of Salamanca and head of the research group of the Ionizing Radiation Laboratory.

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Session Classification : Applications

Track Classification : Applications

Contribution ID : **110**   Type : **Poster**

Absolute peak-efficiency calibration of a well-type germanium detector using multiple gamma-emitting nuclides with the iteration algorithm based on maximum likelihood estimation

Wednesday, 28 September 2016 10:06 (0:02)

Content

The high efficient germanium detectors are powerful tool for low-level radioactivity measurement. Full energy peak efficiencies of these germanium detectors are in general calibrated using a set of gamma-ray emitting reference sources preferably of single gamma-ray emitting nuclides. In order to get such peak efficiency curves for higher energy region, however, we have to use inevitably some nuclides which emit two or more gamma-rays such as Co-60 or Y-88 which may cause dominant coincident summing effects especially for high-efficiency detectors like a well-type detector. Among some methods to solve this problem, analytical method of efficiency calibration was developed and employed in some of commercially available software packages. This is useful for the practical radioactivity measurements, but it is difficult to avoid the inaccuracy arising from the ambiguity of the source-to-detector configuration and also the possible change of active volume or thickness of dead layer in time [1]. As an another approach, Blaauw developed a novel empirical calibration technique using the spectra obtained with a multiple gamma-emitting nuclide having three or more excited states such as Br-82 to obtain the peak and total efficiency functions [2][3]. In the present study, we tried the absolute peak efficiency calibration of a well-type germanium detector along similar idea of Blaauw, but Cs-134 was used in place of Br-82. From measured spectrum, each peak area can be expressed by an equation in terms of source activity, peak efficiency, total efficiency and gamma-ray emission probability. Given the function form for the efficiency curve (e.g. polynomial in log-log expression), the unknown parameters other than the source activity are the coefficients of each term of the efficiency function. In order to determine unknown parameters appeared in the non-linear simultaneous equations, we developed a special iteration algorithm using the maximum likelihood estimation (MLE). The results of activity measurements of non-summing nuclides such as Cs-137 and Mn-54 using the peak efficiency curve thus obtained were consistent with each reference value within 3%. In case of a well-type germanium detector, a reliable peak efficiency curves for an energy-range over 240keV were obtained using Cs-134 reference source. However, efficiencies in an energy range below 240keV cannot be obtainable by use of only one nuclide of Cs-134. Therefore another multiple gamma-emitting nuclide such as Ba-133 might be useful to obtain efficiency curves for lower energy region. The results of these experimental verification will be useful in the radioactivity measurements of low level environmental samples with a high efficiency germanium detector especially with a well-type germanium detector.
Reference [1]Sima O. and, Lépy M-C., Appl. Radiat. Isot. 109, 493-499, 2016. [2]Blaauw M., Nucl. Instrum. Methods in Phys. Res. A 332, 493-500, 1993. [3]Blaauw M. and Gelsema S.J., Nucl. Instrum. Methods in Phys. Res. A 505, 311-315, 2003.

About the Presenter

H.Ishizu will be the presenter.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **112**   Type : **Poster**

Low-level atmospheric radioactivity measurement using a NaI(Tl) spectrometer during aerosol sampling

Thursday, 29 September 2016 12:00 (0:02)

Content

A high-volume (900 m3/h) aerosol sampler operated by SURO within the Czech Radiation Monitoring Network has been upgraded by a NaI(Tl) spectrometric module. The module is placed directly above the aerosol filter which allows for the detection of increased levels of artificial atmospheric radioactivity already during sampling. Standard monitoring regime starts with 3 to 4-day sampling period followed by 8-hour preliminary laboratory measurement. Subsequently, 6-day final measurement is carried out after 3-4 days of decaying. The achieved detection limits for 137Cs measured with a 150 % HPGe spectrometer are approx. 10 μBq/m3 and 0.1 μBq/m3 for the preliminary and final measurement respectively. Although measurement during sampling provides a better time resolution, it is at the expense of lower sensitivity due to the high natural background.

Gamma ray background is composed mainly of 222Rn and 220Rn decay products. This is problematic not only due to the high deposited activity (˜ 104 Bq of deposited activity), but also due to its high variability. The reason for this lies in different radon progenies half-lives and consequently their different activity build-up rate on the filter during the collection process. Rapid changes in the activity ratio between radon decay products in the sampled air are an equally important factor.

The article focuses on the development of a method which could accurately subtract such a complicated background from the measured signal. This goal was achieved by a robust fitting procedure which analyses spectra using a set of background measurements. Based on a given background set, a matrix of characteristic spectra is constructed and serves as an input to the optimization procedure. The sensitivity of this algorithm with respect to false positive alarm rate was studied using radionuclide sources simulating atmospheric contamination by 131I, 134Cs and 137Cs. In addition, complex studies were conducted on the set of real spectra which were artificially injected with impulses in order to simulate various scenarios with different mixtures of chosen artificial radionuclides. The achieved sensitivity for the 1 % false positive alarm rate and 1 h (24 h) measurement period was estimated to 380 (5.6) mBq/m3, 120 (5.1) mBq/m3 and 220 (1.4) mBq/m3 for 131I, 134Cs and 137Cs respectively. This work was supported by the "MOSTAR" project, identification code VG20132015119, funded by the Ministry of the Interior of the Czech Republic

About the Presenter

Mr. Miroslav Hyza has worked at The National Radiation Protection Institute in Prague for the last six years, specializing in the field of atmospheric radionuclides monitoring. He has participated in several major projects related to the research of new concepts and innovation of aerosol sampling devices.

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Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **114**   Type : **Oral Presentation**

Screening test for radioactivity on self consumption products in Fukushima after the Fukushima dai-ichi NPP accident in Japan

Tuesday, 27 September 2016 14:20 (0:20)

Content

After the Fukushima dai-ichi NPP accident, the radioactivity monitoring for legal inspection of foods and foodstuffs has been reinforced to ensure sufficient supply of safe foods. These legal activities are intended to the inspection of radioactivity in foods and foodstuffs distributed through the commercial markets and also to monitoring the radioactivity level of agricultural products grown in the areas where the distribution is restricted by the Japanese government. Furthermore Fukushima and other neighboring prefectural governments have promoted voluntary radioactivity inspections on foods and foodstuffs produced in each prefecture before shipment under the responsibility of producers in order to ensure safety and reliability of their products. However there was no sufficient inspection system for home grown products or wild plants collected by individual consumers for self-consumption. In order to meet such a situation, Consumer Affairs Agency, Fukushima prefectural government and National consumer affairs center of Japan have provided a plenty of NaI(Tl) scintillation spectrometers in public halls or meeting places of the municipalities for screening measurements of radioactivity in wild plants, mushrooms and other products cultivated in private vegetable gardens. In Fukushima prefecture around 500 sets of equipment were installed in about 300 municipal temporary testing laboratories. The tests are carried out in accordance with a specific technical guideline for screening of radio-cesium in foods/foodstuffs by use of a NaI(Tl) gamma-ray spectrometer issued by the Ministry of Health, Labour and Welfare. In 2012fy about 200,000 samples were tested in these laboratories. In 2014fy about 100,000 samples were still screened in these laboratories and above 90 % specimens were passed the test. Since many well-trained staffs should be needed for the adequate use of the instruments and sample preparation, 30 lecture courses on the fundamental knowledge of ionizing radiation and the practice of radioactivity analysis were also provided for total roughly 2,000 staffs engaging for the inspection test. In addition each laboratory can be supported and checked by specialists periodically to maintain and to manage quality of the test. In the present opportunity we will show the inspection system employed for the municipal radioactivity test on home grown products or wild plants collected by consumers for self-consumption in Fukushima. In connection of these experience, applicability and usefulness of the screening method using a NaI(Tl) spectrometer is also represented with results of the tests.

About the Presenter

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Session Classification : Applications

Track Classification : Applications

Contribution ID : **115**   Type : **Oral Presentation**

High Radiopurity Polymer Materials and Their Assay for Ultra Low Background Detector Applications

Tuesday, 27 September 2016 09:00 (0:20)

Content

Ultra low-background radiation measurements are essential to several large scale physics investigations, such as those involving neutrinoless double beta decay, dark matter detection (such as SuperCDMS), and solar neutrino detection. The background radioactivity of the materials used to make and house radiation detectors must be minimized in order to achieve the lowest achievable levels of background signal from the detector. While prior work has focused on semiconductor crystals and metals, there remains a need for high radiopurity polymers and plastics as insulating dielectric materials. It is required that the materials be especially low in U, Th, and K. These materials are needed for structural components, electrical insulation for cables, and seals. Structural dielectric materials are of particular concern. In the past, commercial plastics have either been of poor radiopurity, or have been poor materials for structural insulating parts (e.g., certain polyethylene and polytetrafluoroethylene (Teflon) materials). In addition, plastics with high radiopurity, even if poor structurally, still are only available episodically in pure form. Then each new project needs to find a new source of radiopure insulating plastic. There is a need to move from materials with milliBq/kg levels toward those with low microBq/kg levels. These radiopurity requirements then drive needs for new methods to assay polymers to such low levels. Typical methods for sample preparation for analysis of ppm to ppb levels of metals in plastic are not always directly applicable to the determination of ppt levels of U in plastics, because sample preparation processes can introduce trace level U contamination using conventional methods and containers. In addition, there are no certified reference materials for U or Th in thermoplastics. This talk will describe PNNL's program in sourcing and analyzing polymers for low background applications. By focusing on industries that care about purity, i.e. semiconductor manufacture and biomedical implants, and by focusing on sourcing raw materials, we have identified a number of materials made commercially that have high intrinsic radiopurity. These are compared with a number of additional commerical polymer materials of potentially useful plastics. Using a new assay methods, we have determined levels down to the single digit microBq/kg. We will describe the polymers, the motivation for sourcing them, assay results by new assay methods, and comparison of solid materials with polymer raw materials.

About the Presenter

Dr. Jay W. Grate is a Laboratory Fellow at Pacific Northwest National Laboratory, where his research concerns polymer materials, radiochemical and mass spectrometric analysis, separations, surface chemistry, and sensors.

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Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **116**   Type : **Oral Presentation**

Studies of surface and bulk Po-210 in metals

Wednesday, 28 September 2016 11:00 (0:20)

Content

Surface contamination with long-lived daughters of Rn-222 is of great interest for most of the experiments looking for rare events. These include the detection of low energy solar neutrinos in real time, searches for neutrino-less double beta decay or searches or dark matter. Decays of Pb-210, Bi-210 and finally Po-210 may contribute significantly to the experiments' background, especially when they appear close (external background coming from e.g. construction materials/shields) or directly in the active volumes (internal contamination).

In this paper we present for the first time the results of studies of natural contamination of metal and also Teflon surfaces with Po-210 (U-238 chain, T1/2 = 138 days). Measurements were performed with an ultra-low background, large-areas alpha spectrometer. The instrument allows to study the surface contamination down to about 100 alpha decays per day and per m2. Copper, stainless steel, Titanium, high purity Titanium (produced in a dedicated process for the DarkSide experiment searching for dark matter) and Teflon samples of the size of 43x43 cm and 1 mm thick were investigated. The assay showed no detectable surface contamination of stainless steel and Teflon covered (since the production) with a protective foil against contamination with the air-born Po-210. On the other hand Titanium and commercial ETP (electroformed) copper showed some residual surface activity.

By attributing the counts in the registered spectra in the range of 1.5 MeV to 6 MeV to sub-surface Po-210 we could also investigate the bulk Po-210 contamination (alphas coming from different depths can populate the spectrum up to the 5.3 MeV, which including the energy resolution of the device was extended to 6 MeV). The estimated sensitivity for the bulk contamination for e.g. copper is about 50 mBq/kg, which is presently the best limit (assuming secular equilibrium in the Pb-210 – Bi-210 – Po-210 it hold also for Pb-210). An upper limit for the bulk Po-210 content was obtained for the investigated Teflon sample. Significant amounts of polonium were detected in stainless steel, Titanium, and unexpectedly also in the ETP copper.

We also studied the two most popular surface cleaning methods, which are etching and electro-polishing. They were applied to the investigated copper, stainless steel and Titanium samples. In the course of this study we established that etching has no influence on the copper surface activity and barely influences stainless steel. For Titanium the surface activity was reduced by a factor of about 5. Electro-polishing of copper and steel reduced their surface Po-210 by a factor of about 20, what is consistent with our previous studies performed for samples artificially loaded with high Po activity. By analyzing the Po-210 activity accumulate during electro-polishing on the anode we could also estimate the bulk polonium activity in the polished cathode. In this way by increasing the process time (amount of removed Cu) we are able to improve the detection limit for the bulk Po content in copper.

In the paper we will describe in details the performance of the ultra-low background large surface alpha spectrometer, thanks to which it was possible to study for the first time the natural surface and bulk contaminations of the various samples. We will also provide all the details concerning the measurements procedures and the treatment of the samples.

About the Presenter

Grzegorz Zuzel, Institute of Physics, Jagiellonian University. Involved in the low-background physics. Member of the experiments looking for rare nuclear reactions at low energies: Borexino - detection of low-energy solar neutrinos, GERDA - searches for neutrino-less double beta decay, and DarkSide - searches for cold dark matter particles. Working on background problems in the mentioned projects.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **117**   Type : **Oral Presentation**

Practical implementation of ISO 11929: 2010

Friday, 30 September 2016 11:00 (0:20)

Content

The standard ISO 11929:2010, 'Determination of the characteristic limits (decision threshold, detection limit, and limits of the confidence interval) for ionising radiation measurements – Fundamentals and applications' provides the theoretical background and statistical methods for definition and calculation of 'characteristic limits' (decision threshold, detection limit and confidence limits) of an ionising radiation measurand via the standard measurement uncertainty of the measurand (called the 'standard uncertainty' in the following). The current issue of this standard replaces a previous multipart version that introduced Bayesian statistical analysis techniques as a means to determine these important quantities. As a current ISO standard that has been widely accepted by national bodies, it is expected that laboratories employ the principles and techniques outlined in the document as a basis for calculating decision threshold, detection limit and confidence limits in all forms of radioactivity measurement – particularly if laboratories are accredited to ISO 17025:2005 'General requirements for the competence of testing and calibration laboratories'. Although general formulæ and calculation methods are described in ISO 11929:2010, formulæ for specific measurement techniques, frequently employed by measurement laboratories are not given. In addition, although the formulæ for the calculation of the parameters of the confidence interval parameters omega [U+F077], p and q are given, practical techniques to calculate these terms, upon which the coverage factors kp and kq depend, are not outlined in the standard. The present paper reviews the new ISO approach and proposes exact formulæ for calculation of characteristic limits for integral counting and spectrometry measurements considering the blank and background contributions as well as other uncertainty components, and how commonly used spreadsheet software may be used to calculate aspects of the confidence limits in order to simplify all aspects of the relevant calculations. These formulæ are applied to a number of real cases taken from laboratory practise and characteristic limits are derived as examples. Results are then compared with those obtained from the classical Currie approach and deviations are discussed. Finally, the meaning of characteristic limits are discussed with reference to measurement reporting with the aim to standardise how such reporting is carried out – currently this is often done in a way that makes comparisons of data sets from different organisations difficult.

About the Presenter

Dr de Felice leads the work on Radioanuclide metrology at ENEA.

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Presenter(s) :   Dr. DE FELICE, Pierino (ENEA)

Session Classification :   Quality

Track Classification :   Quality

Contribution ID : **118**   Type : **Oral Presentation**

Re-circulation of FNPP1 derived radiocaesium observed in winter 2015/2016 at coastal region in Japan

Tuesday, 27 September 2016 13:40 (0:20)

Content

Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident in March 2011 released 15-18 PBq of 137Cs (and same amount of 134Cs) (Aoyama et al., 2015) into the North Pacific Ocean as direct discharge of liquid contaminated water and atmospheric deposition. Basin scale observations in the North Pacific Ocean have revealed that the FNPP1 derived radiocaesium has been transported eastward as a speed of a few km per day along surface currents (Aoyama et al., 2015) and relatively rapid southward transport due to subduction of mode waters in the North Pacific Ocean (Aoyama et al., 2016). Although the main part of subducted radiocaesium will be expected back to western North Pacific along sub tropical gyre in a few decades time scale, behaviors of radiocaesium in shallower layers is not understood well. We conducted enhanced surface water sampling at more than 80 stations both in coastal regions at Japan Seas side and Pacific Ocean side of Japan in winter 2015/2016 to reveal behaviors of re-circulation of FNPP1 derived radiocasium in sub-surface/surface layers after five years from the FNPP1 accident in 2011. The volume of samples ranged from a few liter to ten liter and radiocesium in the sample seawater was extracted as ammonium phosphomolybdate (AMP)/ Cs compound (Aoyama et al., 2008). The AMP/Cs compound was measured using ultra-low-background gamma-ray detectors in Low Level Radioactivity Laboratory, Kanazawa University because total amount of 134Cs in the sample was expected to be only a few mBq and those of 137Cs was expected to be around a few to 20 mBq. In the surface layer at coastal region of Japan, 137Cs activity ranged from 1.39+- 0.08 Bq m-3 to 2.00 +- 0.11 Bq m-3 while 134Cs activity ranged from below detection limit (less than ca. 0.2 Bq m-3) to 0.38 +- 0.06 Bq m-3, respectively. A maximum activity of 137Cs in surface water was observed very close to Pacific side of western part of Japan except coastal region of Fukushima which is still affected by leaking fron FNPP1 accident of which release rate of 137Cs is around few Gbq day-1. In Japan sea side, 137Cs activity ranged from 1.63 +- 0.10 to 1.83 +- 0.10 Bq m-3. In the more south of Japan, 137Cs activity ranged from 1.39 +- 0.08 to 1.67 +- 0.10 Bq m-3. These results imply that a small part of FNPP1 derived radiocaesium in the North Pacific Ocean already re-circulate through in sub-surface layer in several year time scale and already reached to Japanese coast. This work partially supported by Grant-in-Aid for Scientific Research on Innovative Areas, the Ministry of Education, Culture, Sports, Science and Technology Japan (KAKENHI), No. #24110005.

About the Presenter

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Presenter(s) : Prof. AOYAMA, Michio (Institute of Environmental Rdioactivity, Fukushima Univ.)

Session Classification : Applications

Track Classification : Applications

Contribution ID : **119**   Type : **Poster**

Evaluation of an early warning system for airborne radionuclides

Thursday, 29 September 2016 12:02 (0:02)

Content

An early warning system for detection of increased levels of radioactivity in outdoor air were operative between 2004 and 2011 at the Swedish air sampling stations. The system consisted of a low resolution detector (NaI), positioned directly behind the filter and measurement of the accumulated radioactivity were performed continuously.

An evaluation of the data collected during the period (consisting of more than 200,000 spectra) is presented with emphasize on natural occurring radionuclides and their influence on the detectability of anthropogenic radionuclides. In addition, the stability of the system as well as difference between the stations are discussed.

Spectra were analyzed every 15 minutes and if the count rate increased significantly an alarm was raised. To determine the sensitivity of the early warning system both laboratory and field measurements with radioactive sources have been performed.

Three different measures for increased count rate have been studied and evaluated: total count rate, ratio between low and high energy regions and regions of interest corresponding to gamma energies of anthropogenic radionuclides.

The laboratory measurements have been compared with measurements at the stations and in particular the problem with short lived radon daughters accumulated at the filter during acquisition has been studied. The levels of radon daughters in outdoor air varies significantly in Sweden and a doubled or tripled count rate for the early warning system due to radon was common at the stations.

The systems sensitivity for anthropogenic radionuclides is therefore dependent of the radon level in the air. Without any compensation for radon variance the system sensitivity ranges from 1 kBq to 100 kBq accumulated activity at the filter, depending on analysis technique and background of radon daughters. For the Swedish air filter stations with an air flow of about 1000 m3/hour this implies that an anthropogenic radionuclide concentration in outdoor air of 1 Bq/m3 could be detected after some hours (if the radon levels are low). This corresponds to the concentration of anthropogenic radionuclides in ground level air in Sweden after the Chernobyl accident.

About the Presenter

PhD in experimental nuclear physics. Currently empolyed as senior scientist at the Swedish Defence Research Agency (FOI).

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Session Classification : Special Session: Monitoring Networks

Track Classification : Special Topic: Monitoring Networks

Contribution ID : **121**   Type : **Oral Presentation**

An integrated bubbler-LSC for on-line measurements of gaseous tritium and carbon-14

Wednesday, 28 September 2016 10:40 (0:20)

Content

Sensitive measurements of tritium or carbon-14 in air require a bubbler to capture and concentrate the activity for off-line liquid scintillation (LSC) measurement. This process is slow and labor intensive. To address these issues, a collaboration between LabLogic Systems Ltd and the National Physical Laboratory (NPL) has been established to develop an automated, on-line radioactive gas monitor. The automation of sample collection, preparation and measurement will reduce labor requirements. On-line measurement will reduce the delay between sampling and measurement analysis.

The proposed instrument is based on LabLogic's on-line radiation-in-water monitor, WILMA. The WILMA instrument has been upgraded to incorporate a bubbler train, furnace and automatic sample transfer which has extended its capability to monitor for HTO, HT, 14CO2, 14CH4 and H-3/C-14 labelled organics in gaseous streams. In addition, the instrument is capable of monitoring for Sr-90, Y-90, Tc-99, Cs-137 and Am-241 in aqueous streams. As such, the instrument is a flexible solution for nuclear sites who may be interested in contaminated ground water, liquid effluent or gaseous discharges.

The specification, design and intended applications of the integrated bubbler-LSC instrument will be presented. This work is partly funded by the EMRP through the MetroDECOM project. The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.

About the Presenter

Steven Bell is a research scientist at the National Physical Laboratory, UK. Steven works within the Radioactivity Group and is responsible for radioactive gas measurement. This includes primary standardization of radioactive gases, calibration of radioactivity-in-air monitors and instrument/method development. Other research interests include gamma spectrometry and spectroscopic X-ray imaging.

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Presenter(s) :   Dr. BELL, Steven (National Physical Laboratory)

Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **122**   Type : **Oral Presentation**

Calibration of a Low Background Gamma Spectrometer for the Assay of Pb-210 in Lead and Comments on Current Availability of Low Background Lead in North America

Wednesday, 28 September 2016 14:20 (0:20)

Content

It is often the case that lead stocks considered for use as shielding in low-background radiation measurement applications are assayed for Pb-210 content to ensure the shielding will not contribute unacceptable background count rates. One traditional method for this assay is via alpha-spectroscopy of the daughter isotope, Po-210, after relatively intensive chemical processing to separate, purify, and electroplate the polonium. In order to reduce the sample processing manpower and timeline requirements, a method for evaluating Pb-210 concentrations was developed via measurement of the bremsstrahlung radiation from beta-decay of the daughter isotope, Bi-210, using a 14-crystal array of high purity germanium detectors. Ten sources of refined lead were assayed, and a selected set of these were used to calibrate the bremsstrahlung-based assay method using previously measured Pb-210 values. The original Pb-210 concentration assay values for these samples were determined through the [U+F061]gamma-spectroscopy method. This calibration was successful, and provides a method of Pb-210 assay that can extend as low as ˜ 2 Bq kg-1 with extended measurement times and limited accuracy (˜25% one sigma). For lead above ˜10 Bq kg-1, the method will provide accuracy of 5% or better, and typical "good" low-background lead (e.g. "Doe Run" lead) with ˜30 Bq kg-1 Pb-210 content can be assayed within about two days of measurement time, and no chemical processing. Subsequent to calibration of the germanium spectrometer, several samples of lead have been assayed via this method. These include both commercially available material and two batches of lead currently stored at Pacific Northwest National Laboratory. These measurements, while nowhere near exhaustive of commercial lead suppliers in the U.S., point out that the loss of lead smelting capacity in the U.S. has eliminated the traditional commercial supply of standard "low background" lead (˜30 Bq kg-1), and current commercial supplies contain roughly an order of magnitude higher Pb-210 levels.

About the Presenter

Martin Keillor is a nuclear engineer who has worked at Pacific Northwest National Laboratory (PNNL) for the past ten years, after retiring from the United States Air Force (USAF). His focus at PNNL is on low-background radiation detection for various nuclear treaty monitoring and national security applications, and he has worked primarily on germanium-based gamma spectrometry and gas proportional detectors.

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Presenter(s) :   Dr. KEILLOR, Martin E (Pacific Northwest National Laboratory)

Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **123**   Type : **Poster**

Radon removal system for the LZ Dark Matter experiment

Monday, 26 September 2016 12:02 (0:02)

Content

There is plenty of indirect evidence from astrophysical observations that Dark Matter exists, and that it constitutes 80\% of the matter in the Universe. However, Dark Matter has not yet been observed directly. The Weakly Interacting Massive Particle (WIMP) is currently the most attractive candidate for the cold Dark Matter. Since WIMPs only interact through gravitational and weak forces, they are extremely difficult to detect. The LUX-Zeplin (LZ) experiment is the most advanced next-generation direct detection experiment to search for Dark Matter in the Universe with a dual-phase liquid xenon (LXe) detector with a total target mass of 7 ton. LXe dual phase detectors proved to be very sensitive probes to search for Dark Matter based on previous experimental results. To be located at the Sanford Underground Research Facility (SURF) in South Dakota, LZ is planning to reach the ultimate sensitivity of 3×10^{-48} cm^2 in three years of operation for a WIMP mass of 50 GeV. To reach such a low detection limit, LZ implements various low background techniques to significantly reduce radioactive background. Radon is potentially the strongest background source that continuously emanates from detector parts and may contribute into the Dark Matter region-of-interest window. Its daughter nucleus, ^{214}Pb, has 6% beta branching fraction to the ground state of ^{214}Bi. The sources of radon include signal cables, feedthrough cables, stainless steel conduits, and dust. An R\&D radon removal system was built to evaluate the most efficient mechanisms to significantly reduce radon traces in the LZ detector. The ultimate goal is to reduce radon levels by more than 90%. The method, apparatus, and detailed experimental results will be presented.

About the Presenter

Postdoctoral fellow at the University of Michigan

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Presenter(s) :   PUSHKIN, Kirill (University of Michigan)

Session Classification :   Radioactive Noble Gases

Track Classification :   Radioactive Noble Gases

Contribution ID : **124**   Type : **Oral Presentation**

Design and Performance of an Ultra-Low Background Cryostat for High-Purity Germanium Spectrometers

Wednesday, 28 September 2016 13:40 (0:20)

Content

High purity germanium (HPGe) detectors are the gold standard for gamma-ray spectroscopy with counting rooms typically employing multiple detectors ranging in type from the standard p-type semi-coax to high-efficiency well detectors. Improving the sensitivity of these measurements is possible by utilizing commercial low-background (LB) HPGe instruments, using carefully designed passive shielding, and employing a cosmic-ray muon veto. If additional sensitivity is required, these instruments can be located in an underground laboratory where cosmic-ray secondary muons, neutrons, and protons are reduced or eliminated. At a certain depth, the trace radioactive impurities remaining in the cryostat and front-end electronics become the dominant background that limits sensitivity. To achieve ultimate sensitivity at deep laboratories, it is necessary to consider the production of a custom ultra-low background (ULB) cryostat. Such a cryostat would be produced with carefully screened materials, fabricated using clean machining practices, cleaned using published ULB cleaning procedures, and assembled in a cleanroom environment.

Recently, a new ULB cryostat has been produced for a custom low-noise (57eV FWHM pulser) large-volume (1.3kg) modified Canberra BEGe crystal. The cryostat design is of the inverted-J type. This design has three benefits – the crystal can be located far from the non-low-background components (Dewar, preamplifier, etc), there is no direct thermal connection to the Dewar (minimize microphonics), and there is no direct gamma-ray shine path onto the crystal. The downside to the design is that the thermal path can be quite long, limiting the operating temperature of the HPGe crystal. Extensive modeling of the new design was performed and indicated a crystal operating temperature of 91.5K, which corresponds exactly to the measured value in final lab testing. In this cryostat, the germanium crystal is mounted in a low-mass holder and surrounded by a thin copper IR shield. By eliminating as much mass as possible and limiting the pallet of materials to electro-refined copper, screened OFHC copper, and clean polymers is it possible to achieve very low backgrounds. Finally, front-end electronics are a significant contributor to background due to their close proximity to the HPGe crystal and the use of non-low-background components. For this cryostat, a custom front-end electronics package was produced, eliminating resistors known to be radioactive.

In this talk I will review the unique features of this cryostat and discuss the fundamental principles in designing, fabricating and assembling an ultra-low background HPGe spectrometer. Deployed to the Soudan Underground Laboratory (1800 meters water equivalent) in late 2015 the detector has been continuously operating; the initial and most recent background spectra from the instrument and projected sensitivity for gamma-assay will be presented.

About the Presenter

Dr. Todd Hossbach is a research physicist in the Radiation Detection and Nuclear Sciences group at the Pacific Northwest National Laboratory. For more than 19 years his research has focused on the design, production, testing, and deployment of radiation detectors and instrumentation for national security and environmental monitoring as well as nuclear and high-energy physics. Since 2001, Dr. Hossbach has been focused on the development of

ultra-low background detectors (semiconductor, scintillation, and gas proportional counters) and detector arrays for the measurement of weak radioactivity in the environment as well as the discovery of rare physics processes.

Primary author(s) :   Dr. HOSSBACH, Todd (Pacific Northwest National Laboratory)

Presenter(s) :   Dr. HOSSBACH, Todd (Pacific Northwest National Laboratory)

Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **125**   Type : **Oral Presentation**

Design, Contruction, and Performance of a New Low-Background, External Source Gas Proportional Counter for Environmental Sample Measurements

Wednesday, 28 September 2016 11:20 (0:20)

Content

A new thin-window, external source beta counter was developed for use in the Pacific Northwest National Laboratory (PNNL) shallow underground laboratory. One driver for this effort was to support the measurement of P-32 for Si-32 sediment age dating; another potential application is the measurement of Si-32 in semiconductor grade silicon to support background calculations for dark matter experiments. The detector design utilizes two thin-window counters, in a clamshell configuration to provide a 4 pi counting geometry. Materials were carefully selected to limit background contributions; during the detector design phase, a detailed background budget was developed. This background projection will be compared with recent background measurements in the PNNL shallow underground laboratory, to demonstrate that the counters have achieved background performance consistent with the preliminary background budget analysis. To achieve the desired background level, the detectors are operated in a copper-lined lead shield that includes borated polyethylene for neutron suppression, active anti-cosmic shielding, and a polycarbonate enclosure to reduce radon and radon daughter activity in the vicinity of the detectors. Materials selected for the Mylar entrance windows and for sample mounting were carefully selected to minimize attenuating layers between the sample and the active gas volume. This effort resulted in measured detection efficiencies approaching 100% for measured beta emitting radioisotopes. Initial measurements with the new beta counter design showed that the detectors were extremely sensitive to ambient high-frequency electromagnetic noise because the detector ends are made of polychlorotrifluoroethylene (PCTFE). This sensitivity resulted in an unacceptably high level of noise for the detectors, and limited their low energy performance / threshold. A new copper carrier was designed to eliminate this sensitivity, as well as to provide a means to stabilize the absolute pressure in the detectors, and to provide an added layer of radiological protection for the clean underground laboratory. This work was entirely successful at eliminating the high frequency noise previously observed in the detectors. This work will present details of the detector and carrier design, compare the original background budget and current background performance, and present other detector performance characteristics.

About the Presenter

Martin Keillor is a nuclear engineer who has worked at Pacific Northwest National Laboratory (PNNL) for the past ten years, after retiring from the United States Air Force (USAF). His focus at PNNL is on low-background radiation detection for various nuclear treaty monitoring and national security applications, and he has worked primarily on germanium-based gamma spectrometry and gas proportional detectors.

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Presenter(s) : Dr. KEILLOR, Martin (Pacific Northwest National Laboratory)

Session Classification : Radiometrics

Track Classification : Radiometrics

Contribution ID : **126**   Type : **Oral Presentation**

INVITED TALK: Our Radioactive Ocean- establishing an ocean monitoring network after Fukushima

Thursday, 29 September 2016 11:00 (0:20)

Content

The triple disaster of the March 11, 2011 earthquake, tsunami, and subsequent radiation releases at Fukushima Dai-ichi were unprecedented events for the ocean and society. US and Canadian citizens became alarmed at the prospect of contaminated elements carried by ocean currents reaching the west coast of North America several years after the event. Although models suggested that radioactive cesium would be at levels well below those considered of human health concern, there was, and remains, no US Federal agencies responsible for monitoring low level ocean radioactivity. In part because of this information gap, the media was full of claims of the dire consequences as a result of Fukushima contamination, including die-off's of marine biota and potential harm to humans living and active along our west coast.

Motivated by this public concern and lack of monitoring, we launched in January 2014 "Our Radioactive Ocean" (http://OurRadioactiveOcean.org), a citizen scientist and crowd funded monitoring network to document the arrival of Fukushima cesium along the North American west coast. The response has been positive, enlisting over 450 donors who have participated in sample collection at over 250 sites, from San Diego to Alaska and Hawaii. Simple 5 gallon sampling "kits" are mailed to groups that successfully fund raise for their site, and results and photos of participants are posted to our web site to share. An internal temperature probe and salinity analyses provide oceanographic context for the radioactive cesium analyses.

We use a research method that is capable of detecting extremely low levels of cesium isotopes in seawater. It includes a Cs extraction step followed by gamma detection on a high-purity germanium well detector for between 24 and 72 hours. We regularly participate in proficiency tests with the International Atomic Energy Agency (IAEA) to ensure that our results are not just precise, but extremely accurate. Cesium-137 has a relatively long half-life (30 years), and it had been present in the ocean since atmospheric nuclear weapons testing that peaked in 1950s and 1960s. Cesium-134 is much shorter-lived (2 years), which means that any detected in seawater samples must have come from Fukushima. Because it was released in equal amounts with cesium-137, we can use its presence to determine how much contamination was released from the Fukushima Dai-ichi reactor site.

Every sample contains detectable cesium-137, with a small but growing number showing cesium-134 indicative of the Fukushima source. The highest total cesium-134+137 attributable to Fukushima was found 1,500 miles north of Hawaii, at levels well below concern for humans or marine life (10 Bq/m3). For example, swimming every day in the ocean at these levels would result in a dose 1,000 times smaller than the radiation we receive with a single dental x-ray. Not zero, but still very low. Looking ahead, levels of any Fukushima contaminants along the West Coast of North America are predicted to peak around 2015 or 2016, but at levels similar to what we are measuring in some of our samples today and lower in fact than cesium levels in the ocean in the 1960's.

A significant effort is spent on the web site explaining basic principles of radioactivity, its sources, uptake in the marine food web, transport with ocean currents, and possible health effects. Links to related media coverage, public talks and outreach materials are posted along side of interactive maps with the data and their sponsors. The more than 500,000 web views in the past 2.5 years, attests to the public concern and interest in this topic.

About the Presenter

Dr. Buesseler is a Senior Scientist at the Woods Hole Oceanographic Institution who specializes in the study of natural and man-made radionuclides in the ocean. His work includes studies of fallout from atmospheric nuclear weapons testing, assessments of Chernobyl impacts on the Black Sea, and examination of radionuclide contaminants in the Pacific resulting from the Fukushima Daiichi nuclear power plants.

Dr. Buesseler has served as Chair of the Marine Chemistry and Geochemistry Department at WHOI, and two years as an Associate Program Director at the US National Science Foundation, Chemical Oceanography Program. In 2009 he was elected Fellow of the American Geophysical Union and in 2011 he was noted as the top cited ocean scientist by the Times Higher Education for the decade 2000-2010. He was honored by the Japan Society for the Promotion of Science with their highest level Fellowship award for overseas researchers. He is currently Director of the Center for Marine and Environmental Radioactivity at WHOI (http://www.whoi.edu/CMER), and regularly speaks to public audiences and engages citizens as part of Our Radioactive Ocean. More info at his "Café Thorium" web site (http://cafethorium.whoi.edu).

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Session Classification : Special Session: Monitoring Networks

Track Classification : Special Topic: Monitoring Networks

Contribution ID : **127**   Type : **Poster**

Accurate measurement 234U/238U activity ratio and 236U/238U isotope ratio measurement in 10-8 range using thermal ionization mass spectrometry

Monday, 26 September 2016 16:50 (0:02)

Content

Variations in the isotope ratios 234U/238U, 235U/238U, and U-236 abundance of natural uranium samples (e.g., uranium ores), are known to exist due to various physical, chemical, mass fractionation, redox transitions, radioactive decay, radioactive disequilibrium, alpha-recoil, and neutron capture. Precise measurement of uranium isotope ratios with sufficient accuracy is a challenge to resolve the range of natural variation in a representative set of samples. 234U belongs to the 238U natural radioactive decay series, and at equilibrium, the abundance ratio, 234U/238U, corresponds to their half-lives, i.e. 54.8 x 10-6. Measurement of 235U/238U isotope ratio is more suitable to check for uranium scatter from nuclear power plant accident origin. This is because the existence ratio of the 235U and the 238U is different in the uranium which exists naturally and the uranium included in nuclear fuel.

Uranium was chemically separated from uranium ore as well as some soil samples affected by Fukushima accident and its isotopic composition was measured using a thermal ionization mass spectrometer (TIMS). Chemical separation of U was carried out by two-column separation procedure using UTEVA resin and UTEVA resin. Since Japanese soil samples contain a large amounts of Fe and it makes U isotope ratio measurement difficult. Therefore, we separated U with UTEVA resin twice.

The TIMS (Phoenix, IsotopX, UK) used has nine Faraday cups collectors and a Daly ion-counting system detector positioned behind axial Faraday and WARP (wide aperture retardation potential) filter. The WARP filter is designed to suppress the tailing effect. Abundance sensitivity of 236U using NBS 030a was 5.86ppm. The limit of detection for 236U/238U measurements using Daly ion counting system with WARP is about 2x10-9 to 4x10-9. This was evaluated using certified natural uranium reference materials from University of Vienna in house standard in the order of 1.01x10-8. This method for uranium isotopic composition has been shown to significantly improve the precision and accuracy in analysis of environmental samples. Results will be discussed in detail during presentation.

About the Presenter

I am working as a researcher at National Institute for Quantum and Radiological Science and Technology wef February 1997 as a permanent employee. My field of specialisation is development of methods for precise isotope ratio determination using TIMS. I have worked on Li, Zr and U isotope ratios. I have worked with meteoric samples for Zr isotope ratio measurement. Recently I am focussing on Fukushima related environmental radioactivity related measurements.

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Session Classification : Non-radiometric Measurements

Track Classification : Non-radiometric Measurements

Contribution ID : **129**   Type : **Oral Presentation**

Characterization and calibration of a novel detection system for real time monitoring of radioactive contamination in water processed at water treatment facilities

Wednesday, 28 September 2016 09:00 (0:20)

Content

A novel detection system was designed and constructed in the frame of the TAp WAter RAdioactivity Real Time Monitor (TAWARA_RTM) project, financed by the EU under the FP7 research programme (FP7-SEC-2012-1). The TAWARA_RTM system is intended to be used for real time monitoring of radioactive contamination in water processed at water treatment facilities providing fast radiological alarm and radionuclide identification. The system is based on three different units. An Early Alarm Detector (EAD), based on a gamma-ray monitor, for gamma radioactivity early detection. A Real Time Monitor (RTM), based on a number of plane windowless ZnS scintillation detectors, is used for continuous monitoring of gross alpha and beta radioactivity in water. In case of any positive detection (gamma, alpha or beta) water samples are further analysed by a Spectroscopy Detector (SPEC) equipped with ion-exchange resin concentrator and aiming at radionuclide identification and quantification. Signals form all TAWARA detectors are processed by modern digitizing techniques. Dedicated software as well as ICT infrastructure were developed for system operation and alarm management. The TAWARA_RTM platform was conceived to detect a gross alpha/beta activity of the order of 1 Bq/l in several tens of minutes. Detailed description of the design and construction are reported in [1]. A number of characterization tests and calibration measurements were carried out, during the last part of the project, at the National Institute of Ionizing Radiation Metrology of ENEA (Italian Primary Metrology Institute for ionising radiation). This work is described in the present paper. As far as possible, tests were carried out with reference to available national and international Standards such as those issued by CEN, IEC and ISO. Reference radiations and radionuclides for testing and calibration were chosen in order to reflect energy ranges and radiation types of the major water radioactive contaminants possibly arising from environmental, industrial or terroristic origin. The following radionuclides were used: Am-241, Sr-90, F-18, Co-60, K-40, Cs-137, Cd-109, Ce-139, Y-88, Co-57, Sn-113. Starting from single-nuclide aqueous solutions, a set of spiked water reference materials were developed and calibrated with traceability to the ENEA national standard of radionuclide activity. Calibrations were carried out in field-close conditions simulating, as far as possible, the application of the instrument to the intended use. To this purpose a special standard radioactive-water-generator was constructed to allow transfer of water reference material samples from original vessels into the instrument, simulating water sampling from a pipeline. Special precautions and solution treatment were required to avoid internal contamination of system detectors. Liquid solutions were complemented by solid point and annular sources prepared on plastic supports and hermetically sealed for system check and SPEC calibration. The following instrument parameters were tested: sensitivity, selectivity, background, short/long term stability, linearity with respect to activity, defined as the amount of error change throughout the instrument's measurement range, identification of main external influence parameters (temperature, relative humidity, air pressure, water acidity and chemical composition, accuracy of software algorithms for calculation of measurement results and associated uncertainties.

[1] TAWARA collaboration, "TAWARA_RTM - the Detection System for Real Time Monitoring of Radioactive Contamination in Water Processed at Water Treatment Facilities",

paper accepted for poster presentation at the Symposium on Radiation Measurements and Applications-West Coast (SORMA West 2016), University of California, Berkeley, USA, 22-26 May 2016.

About the Presenter

Dr De Felice leads the work on Radioanuclide metrology at ENEA.

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Presenter(s) :   Dr. DE FELICE, Pierino (ENEA)

Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **131**   Type : **Oral Presentation**

Development of an optimised method for analysis of strontium-90 in decommissioning wastes by triple quadrupole inductively coupled plasma mass spectrometry

Monday, 26 September 2016 14:40 (0:20)

Content

Inductively coupled plasma mass spectrometry (ICP-MS) has traditionally been applied to measurement of long-lived radionuclides, as the slow decay rate means ICP-MS offers a higher sample throughput and improved limits of detection compared to alpha and beta counting techniques. As instrumental capabilities have improved, ICP-MS is at a stage where it is capable of measuring shorter-lived radionuclides at activities rivalling radiometric techniques. In the case of 90Sr (half-life 28.8 years), this has the potential to offer significant economic benefits to nuclear sites, as the sample throughput is significantly improved over liquid scintillation counting techniques, the current routine approach for the majority of nuclear sites.

The critical factor affecting ICP-MS measurement of 90Sr is removal of multiple stable interferences prior to measurement, namely isobaric overlap from 90Zr, peak tailing from 88Sr, and multiple polyatomic interferences that form by reactions of elements with gases in the plasma and/or instruments with a reaction cell e.g. 58Ni16O2 and 74Ge16O. The latest generation triple quadrupole ICP-MS (ICP-QQQ-MS) offers an advance in removal of interferences affecting 90Sr compared to alternative instrumental setups. The two quadrupoles either side of a collision-reaction cell effectively removes peak tailing from 88Sr, whilst the introduction of oxygen as a reactive gas into the cell removes the mass overlap of 90Zr through the formation of 90Zr16O. Additionally, the quadrupole positioned in front of the cell prevents the formation of secondary oxide-based polyatomic interferences in the cell. This instrumental setup can be used in combination with or instead of radiochemical separation, reducing the total procedural time and further improving sample throughput.

This work presents the results from a Nuclear Decommissioning Authority (NDA)-funded project for the development of robust, reproducible procedures for low-level measurement of 90Sr in decommissioning samples (soils, sediments and cement) by ICP-QQQ-MS. Results are presented for the performance of multiple sample digestion (acid leaching, microwave and lithium borate fusion) and radiochemical separation techniques, with a focus on achieving complete 90Sr recovery and decontamination of interferences. This is combined with optimisation of ICP-QQQ-MS for both 90Sr sensitivity, and removal of interferences using the triple quadrupole setup. The results from liquid scintillation counting measurement of the same samples will also be presented, allowing direct comparison of the two techniques with regards to procedural time, sample throughput, and limits of detection achievable.

About the Presenter

Ben Russell completed his PhD at the University of Southampton in 2014, investigating the application of sector field inductively coupled plasma mass spectrometry (ICP-SFMS) for low-level nuclear waste characterisation, focussing on measurement of caesium-135/caesium-137 isotopic ratios and strontium-90. The project combined novel and efficient chemical separation techniques with high sensitivity ICP-SFMS quantification, resulting in three lead-author peer-reviewed papers with a invited ICP-MS review paper in draft. Ben now

works in the radioactivity group at the National Physical Laboratory, London, with his primary role being to assess the radioanalytical capability of a novel ICP-MS/MS instrument.

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Presenter(s) :   Dr. RUSSELL, Ben (National Physical Laboratory)

Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **132**   Type : **Oral Presentation**

Rapid low-level analysis of 226Ra in groundwater samples by latest generation triple quadrupole ICP-MS

Monday, 26 September 2016 14:20 (0:20)

Content

Exploitation of mineral resources creates waste in which natural radioactive decay series isotopes, in particular 226/228Ra, 210Pb and 210Po, are often concentrated to levels that are hazardous to human health. Consequently, producers are required to comply with very stringent limits when discharging to water courses. In the United Kingdom, the discharge limit for 226Ra is 10 mBq L-1; however, 226Ra is naturally present in groundwaters where its abundance depends on local geology. Such a low regulatory target presents a serious challenge when differentiating between natural background and industrial contamination. Low-level measurements of 226Ra (half-life 1,600 years) are predominantly carried out using alpha spectrometry, which requires extensive chemical separation, followed by count times of several days to accurately determine the 226Ra content. Inductively coupled plasma mass spectrometry (ICP-MS) offers an alternative technique for detection of 226Ra, with a measurement time of only several minutes per sample. The major issues are matching the detection limits achievable by radiometric techniques and removal of potential polyatomic interferences (including 88Sr138Ba, 87Sr139La and 86Sr140Ce) that overlap with 226Ra; this usually necessitates complete chemical separation prior to measurement. A method has been developed using the latest generation triple quadrupole ICP-QQQ-MS that effectively removes these interferences without the need for prior chemical separation. The slight reduction in instrument sensitivity by introducing helium as a collision gas into the collision-reaction cell is offset by removing the contribution of interferences to the instrument background. The optimised setup has measured groundwater samples at 226Ra concentrations down to 1 Bq L-1 without prior chemical preparation. A combination of ICP-QQQ-MS with suitable pre-concentration should, therefore, result in a novel technique capable of measuring 226Ra at activities relevant to water discharge limits, whilst negating the need for extensive chemical separation and long count times, significantly increasing sample throughput.

About the Presenter

Elsje van Es is a 2nd year PhD student affiliated with University of Surrey, UK, under the supervision of Prof David Read. She is currently working in the radioactivity group at the National Physical Laboratory, London, with Dr Peter Ivanov, Dr Ben Russell and Maria Garcia-Miranda. Her research there is focused on the development and validation of rapid methods for the determination of 226Ra in low activity groundwater samples, with the intent of implementation within a mobile laboratory environment. The project includes improving existing methods complimenting standard radiometric analysis techniques as well as developing new methods for use with the department's novel ICP-MS/MS instrument.

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Presenter(s) :   Ms. VAN ES, Elsje (University of Surrey)

Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **136**   Type : **Oral Presentation**

Application of Δ14C and δ13C to trace sources of organic carbon in Baltic Sea sediments

Monday, 26 September 2016 16:10 (0:20)

Content

Radioactive and stable isotopes have been widely used to trace the origin and fate of organic carbon (OC) in the environment. They were applied to identify sources of OC in the marine environment. Microbial communities responsible for biodegradation of different origin organic contaminants can produce specific biomarkers. The application of carbon isotopes in combination with compound-specific analyses and microbial biomarkers is promising tool since specific microbiological degradation can occur in the contaminated sediments, which can lead to assimilation of toxic compounds and their degradation products. Releases of specific microbiologically-derived lipids into the environment with carbon isotopic composition unusual for the given area can serve as an indicator of contamination of the marine environment. The Δ14C and δ13C of total organic carbon (TOC) in surface (0-3 cm) bottom sediments as well as in humic acids, lipid and phospholipids (PL) fractions isolated from the bottom sediment samples collected in the Curonian Lagoon and in the open Baltic Sea were investigated. The δ13C measurements of phospholipid – derived fatty acid methyl esters were carried out with Finnigan Trace GC ultra gas chromatograph, combined with Thermo Finnigan Delta plus Advantage stable isotope spectrometer. The column used for the fatty acid methyl esters measurement was a Supelco SPTM-2380 capillary column with 0.25 mm internal diameter, 30 m in length and of 0.2 μm film thickness. Measurements of Δ14C in sediments and in different classes of organic substances were carried out by using a 1.0MV HVE Tandetron AMS. The phospholipid-derived fatty acid biomarkers and a different end-member (EM) mixing model approach were applied to estimate the relative contribution of the marine and terrestrial input to OC in the coastal and open sea surface sediments, assess a possible effect of petroleum hydrocarbon HC contamination on radiocarbon signatures and to elucidate a probable leakage of chemical warfare agents (CWA) at the CWA dumping site in the Gotland Deep. The most depleted values of the Δ14C of the TOC and the total lipid fraction were detected at the CWA dumping site. Application of EM mixing-model-analysis and measurements of total petroleum hydrocarbons (THCs) allowed estimation of OC sources (terrestrial, marine, fossil and THC) in studied sediments. The compound-specific method was applied to estimate the possible effect of CWA on depleted Δ14C and δ13C values.

About the Presenter

Dr. Galina Lujanienė, Head of Radiochemical Laboratory, SRI Centre for Physical Sciences and Technology
She has graduated from the University of Vilnius, Department of Chemistry, (M.Sc., Chemistry of natural compounds). She received her Ph.D. degree in chemistry from the University of Vilnius (Physical and chemical characteristics of radionuclides in the environment) in 1993. Presently, she is a head of laboratory at the Center for Physical Sciences and Technology in Vilnius. She has been involved and leading a number of national and international projects devoted to environmental radioactivity and waste management. She has published over 100

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Session Classification : Non-radiometric Measurements

Track Classification : Non-radiometric Measurements

Contribution ID : **139**   Type : **Oral Presentation**

DoseNet: building scientific literacy through a network of radiation detection devices

Thursday, 29 September 2016 16:25 (0:20)

Content

After the Fukushima Daiichi nuclear power plant accident in March 2011, there was a great deal of misinformation and fear on the western coast of the United States regarding radiation from the damaged power plant in Japan reaching US residents. This fear reflects the general public's lack of understanding of radioactivity in our environment and how to assess risks associated with radiation exposure. More generally, this response exposed a lack of scientific literacy in our community. The RadWatch outreach organization was formed to address these concerns by providing transparent, relevant measurements of radioactivity in our environment. The newest component of this ongoing effort is the DoseNet project, a multidisciplinary undertaking to educate the next generation about radiation science, improve scientific literacy, and improve our communication of technical concepts to our communities. We are actively building a network of radiation measurement devices (dosimeters) deployed at schools around the Bay Area and at several international locations, with the data collated and displayed through our website (radwatch.berkeley.edu/dosenet). Our network provides students with access to real-world background radiation data and the tools to analyze this data. Students will also have the opportunity to be involved in hands-on work with these radiation detection devices, as well as future developments such as the addition of new types of sensors (CO_2, UV, etc.). This project will therefore engage students at all levels and allow them to "see" and learn what is normal in our world by applying fundamental science and engineering concepts.

About the Presenter

Postdoctoral Researcher working jointly in the Physics and Nuclear Engineering departments at the University of California, Berkeley.

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Session Classification :   Metrology and Citizen Initiatives Workshop

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **141**   Type : **Poster**

Digital gamma-gamma coincidence HPGe system for environmental analysis

Wednesday, 28 September 2016 14:44 (0:02)

Content

In order to decrease the detection limits for gamma-ray spectrometry it important to reduce the background. One of the promising techniques that may be used to accomplish this for coincident gamma emitters is gamma-gamma coincidence spectrometry. The progress of construction on the new coincidence spectrometer system installed at the Centre for Nuclear Technologies of the Technical University of Denmark and intended for environmental samples analysis is reported. Nutech Coincidence Low Energy Germanium Sandwich (NUCLeGeS) system consists of two Canberra (GL3825R) detectors placed in a surface laboratory in low activity lead shield and digital acquisition system used to collect the data in a time stamped list mode file with 10 ns time resolution. After the coincidence identification and basic data manipulation the spectrum is converted to .CAM format and GENIE2000 software is used for the further activity calculation. The capability of the new system is demonstrated in the case of multi-gamma emitters, 134Cs in the high 137Cs background, and single-gamma emitters, 210Pb in environmental samples. In the first case coincidence gated spectrum is extracted in order to reduce the background, while in later the coincidence spectrum was subtracted from the total for the Compton background removal. The system is compared to single HPGe gamma spectrometer of higher efficiency and to well-HPGe system with the NaI anti-Compton shield. Results are discussed in the scope of the optimum sample shape and size that can be used in the each system. Gamma-gamma coincidence spectrometry proved as the only effective way to reduce the 137Cs background in spectrometric determination of 134Cs, which is of importance in tracer applications in oceanography or to examine Chernobyl impact in environmental samples. The system also proved as effective in 210Pb determination, being able to accept bigger sample sizes than the well-shaped spectrometer and having greater efficiency and lower background in comparison to the single detector system.

About the Presenter

Nikola Markovic is a PhD student at Center for Nuclear Technologies, Technical University of Denmark.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **143**   Type : **Oral Presentation**

Low-Background Gamma Spectrometry for the International Monitoring System

Thursday, 29 September 2016 15:00 (0:20)

Content

The International Monitoring System of the Comprehensive Test Ban Treaty Organization includes a network of 80 field stations and 16 laboratories dedicated to the detection and analysis of airborne particulates to detect possible nuclear events that could indicate a violation of the treaty. PNNL has operated a certified laboratory, USL16, since December 2007. In the last few years, PNNL has developed two very low-background gamma detectors housed in a new shallow underground laboratory. This new capability significantly improves our ability to detect trace amounts of airborne particulate that may be present in samples from the IMS field stations. The new underground laboratory at PNNL is at about 50 feet below ground with an overburden resulting in about 30 meters water equivalent. The detectors are located in a lab that operates as a class 10,000 clean room. The gamma detectors have a relative efficiency of about 100% and they were built by Canberra to PNNL specifications. All the detector components of the detector are fabricated from very low background materials. The shield consists of 20 cm of low background lead lined with 5 cm of oxygen-free high thermal conductivity (OFHC) copper. Five large cosmic veto panels surround the detectors and shields to suppress cosmic ray induced events. The entire assemblies are enclosed in a glove box that has a high flow of dry nitrogen gas from the boil off of a large liquid nitrogen tank outside the building. Samples are introduced and removed from the detector using a pass through that is flushed with nitrogen prior to opening to the detector enclosure. The cosmic veto nearly eliminates the 511 keV peak; the dry nitrogen flow greatly reduces the radon peaks; and the low background detector materials eliminate naturally occurring peaks such as the 1460 keV peak from 40K. The holders for the IMS samples were designed and fabricated with a 3D printer using ABS plastic. Overall, the background count rates for the new detectors are reduced by about a factor of 100 compared to an off the shelf commercial gamma detector operating above ground at our laboratory. The typical background count rate is about 0.05 counts per second over the range of 40 to 2500 keV. Since the minimum detectable activity (MDA) depends on the square root of the background count rate, this reduces the MDA for the 537 keV peak from 140Ba to about 3 mBq for a 7 day count, following the IMS prescribed method.

About the Presenter

Dr. Greenwood is a Laboratory Fellow at Pacific Northwest National Laboratory. He operates a certified laboratory for the International Monitoring System of the Comprehensive Test Ban Treaty Organization. He has a Ph.D. in Nuclear Physics. Research interests include radiation detection, nuclear data, reactor dosimetry, nuclear forensics, production of medical isotopes, and radiation damage in materials.

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Presenter(s) :   Dr. GREENWOOD, Larry (Pacific Northwest National Laboratory)

Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **145**   Type : **Oral Presentation**

Black Hills State University Underground Campus

Tuesday, 27 September 2016 16:50 (0:20)

Content

The Black Hills State University Underground Campus (BHUC) is a multidisciplinary facility located at the 4850 foot level of the Sanford Underground Research Facility (SURF) in Lead, SD. The 4300 m.w.e. overburden provides a substantial reduction in cosmic ray muon-related backgrounds in sensitive detectors underground. Located within the BHUC is a 600 sq. ft., class 1,000 cleanroom dedicated to low background counting. Amenities of the cleanroom include vacuum-jacketed piping for liquid nitrogen running along the wall, serving each low background counting station with remotely-controlled solenoid valves and an autonomous LabVIEW fill program. Each counting station is also provided with nitrogen for purging, electrical outlets and data connections. Personnel from Black Hills State University (BHSU) are on-site to provide assistance with the maintenance and operation of detectors for remote users.

Since the completion of the BHUC in August 2015, three high purity germanium (HPGe) low background counting stations have been installed, with five more expected by the end of the year. It is anticipated that the BHUC will house up to twelve HPGe counters and small scale R&D efforts. In addition to HPGe counters, an XIA alpha counter is expected to move underground and one user group is pursuing funding for a beta counter. An Inductively Coupled Plasma Mass Spectrometry (ICP-MS) system rounds out the capabilities, located just 20 miles away at the BHSU above-ground campus. The BHUC is a user facility and open to accepting new counting stations as space allows, including opportunities for R&D testing and small scale experiments in a deep underground clean room.

A collaboration of BHUC low background counter owners is being formed to organize and simplify incoming counting requests and share resources amongst users of the facility. While the collaboration is currently concentrated on particle astrophysics samples, it is open to counting samples for any application. This talk will provide a detailed overview of the facility and the network of counting services that this facility seeks to provide the low background community at large.

About the Presenter

Dr. Brianna Mount is research faculty at Black Hills State University and the lab director of the BHSU Underground Campus. She also runs an ICP-MS lab at the above-ground BHSU campus, located just 20 miles away from the Sanford Underground Research Facility.

Primary author(s) :   Dr. MOUNT, Brianna (BHSU)

Presenter(s) :   Dr. MOUNT, Brianna (BHSU)

Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **146**   Type : **Poster**

COMPUTATIONAL APPROACHES ON PHOTON-ATTENUATION AND COINCIDENCE-SUMMING CORRECTIONS FOR THE DETECTION OF GAMMA-EMITTING RADIONUCLIDES IN FOODS

Tuesday, 27 September 2016 17:14 (0:02)

Content

The U.S. Food and Drug Administration (FDA) faces increasing challenges in safeguarding the nation's food supply against growing threats of nuclear power accidents, global nuclear proliferation, and nuclear facility breaches. To ensure food safety and protect public health, it is imperative that the FDA is capable of rapid and reliable detection and quantification of gamma-emitting radionuclides in foods in the event of a large-scale nuclear or radiological emergency. Gamma-ray spectroscopy is the method of choice for identifying and quantifying gamma-emitting radionuclides and was previously implemented for food analysis in the FDA's radiological laboratory. However, the current method used and its further applications are constricted by the cost and availability of mixed gamma calibration standards needed for counting efficiency corrections that compensate for differences in matrix compositions, food densities, and sample geometries. Furthermore, the lack of suitable calibration standards to facilitate coincidence summing corrections for close volumetric counting geometries, make accurate radionuclide quantification difficult. Source-based calibration methods used for photon attenuation and coincidence summing corrections are time consuming and require multiple certified standards that match sample geometry with varying densities. To overcome these difficulties, a number of software and modeling techniques, which are capable of simulating a variety of sample geometries, matrix compositions, and sample densities have been examined as an alternative calibration method. This study investigated the accuracy of calibration measurements of foods containing known amounts of radionuclides by using both traditional source-based methods and computational methods so that a direct comparison between them can be made. The three different programs evaluated in this work were GESPECOR, Angle 3 by ORTEC and LABSOCS by Canberra. In this study, foods of various densities were examined to understand the relationship that different food matrices have on efficiency calibrations. Organic solutions were also used to improve the scope of densities studied. Efforts were focused on determining the accuracy of these measurements by comparing the results of the software to the measurement of spiked food samples. From the results, it was determined that LABSOCS was the most accurate at replicating measured efficiencies. All of the software packages provided predicted activity levels in the various food samples that are significantly more accurate in comparison to using a water-based efficiency to estimate activity. From the results, a correction factor for density was derived and can potentially be used to eliminate the process of generating a different standard for samples of interest.

About the Presenter

Dr. Rolle completed his Ph.D in Inorganic Chemistry at Georgia Institute of Technology where his work focused extensive research experience in the synthesis and characterization of small molecules. Afterwards he pursued a postdoctoral fellowship at Johns Hopkins University

in Chemistry. In his studies, he has investigated the development of environmentally benign transition metal catalysts, as solutions to outstanding problems in bench-top organic synthesis, commodity chemical production and energy storage. Currently, he is Commissioner's Fellow at the Food and Drug Administration with research interests in reducing the impact that anthropogenic sources of chemicals have on human health and the environment.

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Presenter(s) : Dr. ROLLE, Clarence (Food and Drug Administration)

Session Classification : Applications

Track Classification : Applications

Contribution ID : **147**   Type : **Poster**

Small Volume Assay Method for 210Pb/Po in Lead

Wednesday, 28 September 2016 12:02 (0:02)

Content

Sensitive radiation detections systems most commonly utilize refined lead to shield the detectors from background radiation. Selecting lead with the lowest intrinsic radioimpurities is important to reduce the background to levels such that the sensitivity of the detection system can be maximized. Lead shields are designed in a scaled approach such that the lead with the highest levels of radioimpurities is furthest from the detectors while the more radiopure is closest, serving as a shield to the more contaminated lead. Radioimpurities are primarily 238U and 232Th decay-chain isotopes and are present naturally in the ore from which lead is refined. The radioactive lead isotope, 210Pb (238U decay chain), becomes substantially out of secular equilibrium with its parents due to the lead refinement process. This isotope can be measured directly via gamma spectrometry, but to do so requires kilogram sample sizes and long count times. The 210Pb content can also be inferred by quantifying the alpha emissions of its daughter 210Po if the lead is sufficiently old enough to ensure that secular equilibrium has been established. In the past, antiquity lead shielding was used for low-background detectors due to the relatively short half-life of 210Pb of 22.2 years, but the availability and cost of this lead can be prohibitive. As the loss of lead smelting capacity in the U.S. has eliminated the traditional commercial supply of standard "low background" lead, a systematic approach to cleanly assay commercially available lead stock for 210Pb content is required to determine the suitability of a given lead supply for a given shielding design. One such method for assaying 210Pb concentration using small sample sizes and small volumes of ultra-high-purity reagents has been developed. The results of assaying lead from ten different lots are presented. The 210Pb concentrations ranged from ~0.1 – 75 Bq/kg, as inferred by the 210Po alpha quantitation.

About the Presenter

Shannon M. Morley (B.S., Chemistry, University of Montana, 2003) is a research scientist at Pacific Northwest National Laboratory. Ms. Morley is an experienced radiochemist and has focused her contribution to multi-faceted projects primarily through chemical separations, alpha energy analysis, and gamma energy analysis. Additional research and programmatic activities include nuclear accident dosimetry response, Hanford Groundwater Remediation quality control support, treaty monitoring via the International Atomic Energy Agency, and nuclear non-proliferation. She has authored peer-reviewed publications, and has been actively involved in nuclear forensic education through the development of and participation in the IAEA/NNSA International Workshop on Nuclear Forensic Methodologies.

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Presenter(s) :   Ms. MORLEY, Shannon (Pacific Northwest National Laboratory)

Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **148**   Type : **Poster**

Low-Background Radioxenon Detector

Thursday, 29 September 2016 15:24 (0:02)

Content

The measurement of radioactive xenon (Xe-131m, Xe-133, Xe-133m, Xe-135) in the atmosphere is one of the fundamental approaches to monitor nuclear explosions. The ratios of the four radioxenon isotopes provides the ability to discriminate between a nuclear explosion and other anthropogenic backgrounds such as nuclear reactors. A definitive method for detecting radioxenon is beta-gamma coincidence, in which an inner plastic scintillator cell detects the beta particle, and an outer NaI detector detects the gamma. Measurements of these isotopes via beta-gamma coincidence can be improved by replacing the scintillating plastic β-cells with silicon detectors which have a higher energy resolution. In addition to a higher resolution, silicon detectors do not suffer from xenon diffusing into pores leading to a memory of the previous measurement. An increase in resolution allows for minimization of interferences and a narrowing of the regions of interest of each isotope. In return, this allows for lower minimum detectable activities of radioxenon, quicker measurements for an increase time resolution, and lower backgrounds. A silicon-based CE/β detector cell with higher resolution has been developed by the French Atomic Energy Commission (CEA) and commercially produced by Canberra as the PIPSBOX-2x1200-500A. This detector operates in PNNL's Shallow Underground Laboratory using a high purity germanium Dual Up-looker Down-looker Detector System (DUDDS) inside of a low background shielded cave with cosmic veto panels allowing for unparalleled measurements. Measurements of the pure xenon isotopes allows for definitive determination of the region of interest. Additional measurements of environmental samples from around the world provide insight into the potential limits for the radioxenon-monitoring regime. We report on the measured efficiencies, detection limits, and memory effect of the Canberra PIPSBOX-2x1200-500 in the ultra-low level background environment as well as the results from measurements of environmental samples.

About the Presenter

Dr. Michael Foxe is a staff scientist who joined PNNL as a post-doc in 2013, and has been in the field of radiation detector development since 2007. He spent 6 years at Lawrence Livermore National Lab on the development of a liquid argon detector for nuclear safeguards and nonproliferation as well as dark matter detection. The liquid argon detector was the first of its kind to demonstrate sub-keV spectroscopy through 37Ar detection. He also worked on developing a radiation detector using graphene and a directional fast neutron detector for the Department of Homeland Security. Since joining PNNL, he has been involved in the development and characterization of various radiation detectors focused on the detection of radioxenon and radioargon for treaty verification. He also stays involved with the dark matter and neutrino community through liquid noble gas detector work.

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Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **149**   Type : **Poster**

Radon Emanation Screening for LZ

Monday, 26 September 2016 12:06 (0:02)

Content

The LUX-ZEPLIN experiment will be a two-phase xenon dark matter detector. The decays of radon daughters, which can migrate into the fiducial volume, are expected to produce a significant background. In order to help ensure a sufficiently low concentration of radon within the xenon volume, the project has embarked on a program to screen all materials that will be in contact with the xenon. We will describe the operation of the four screening devices employed by the project, which are located at UCL, SDSM&T, UA, and UMd and are each sensitive to the emanation of 2 mBq or less of 222Rn. The large, 300L vessel at SDSM&T provides an important ability to screen large samples. Finally, we will present results from the first assays performed for this radon emanation screening program including various cables, electronic components, welds, and epoxies.

This abstract is part of a coordinated submission by the LZ collaboration.

About the Presenter

Dr. Eric Miller is a Postdoctoral Research Scientist at the South Dakota School of Mines & Technology. He obtained his Ph.D. in 2015 from the University of New Mexico. He will be presenting on behalf of the LZ Collaboration.

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Presenter(s) :   Mr. MILLER, Eric (South Dakota School of Mines)

Session Classification :   Radioactive Noble Gases

Track Classification :   Radioactive Noble Gases

Contribution ID : **151**   Type : **Poster**

Isotopic Analysis of Plutonium in Foods by Inductively-Coupled Plasma Mass Spectrometry

Monday, 26 September 2016 15:00 (0:02)

Content

Globalization of the food supply presents immense food safety challenges to the U.S. Food and Drug Administration (FDA). Concerns have increased regarding the possibility that food could become contaminated with radioactive materials due to ageing nuclear facilities, global nuclear proliferation, and breaches in the safeguard of nuclear materials. In response to the impending threats, considerable efforts have been put forth in developing sensitive, rapid, and robust analytical capabilities to support radiological emergency response. In the aftermath of a nuclear or radiological incident involving dispersion of plutonium radioisotopes, a large number and variety of foods will need to be analyzed for 238Pu, 239Pu, 240Pu, and 241Pu. While 238Pu and 241Pu are readily detectable using traditional radiometric methods, quantifications of 239Pu, 240Pu, and 239Pu/240Pu ratio require use of mass spectrometry to distinguish between Pu from nuclear power plants and from global nuclear fallout. Given the unique toxicity of Pu, any method developed for the purpose of regulatory compliance must have an ability to detect Pu at a concentration of below 0.67 Bq/kg which is equivalent to 1/3 of the FDA recommended derived intervention level (DIL).

In this study, inductively-coupled plasma mass spectrometry (ICP-MS) in combination with Aridus II desolvating nebulizer system and efficient radiochemical separation for removing complex food matrices and polyatomic interferences were developed and used to detect Pu isotopes in various types of foods. The developed radiochemical procedure involves rapid wet ashing of foods, selective extraction of Pu using N,N,N',N'-tetra-n-octyldiglycolamide (DGA Resin, Normal), and removal of UH+ interference using a desolvating nebulizer. A large number of samples can be run as a batch, and the method is amenable to automation for high throughput analysis.

A variety of foods including vegetable, grain, meat, dairy, and complex meal were used for method development and validation. Each food sample was spiked with known amounts of 239Pu, 240Pu, and 242Pu, digested using a mixture of concentrated hydrogen peroxide and nitric acid, chemically purified with 1 gram of DGA resin, and analyzed for 239Pu, 240Pu, and 239Pu/240Pu ratio. The experimental studies demonstrate that the developed method is capable of detecting Pu in food at a concentration level significantly below 1/3 of FDA DIL within 5 hours of receiving a sample. A detailed radioanalytical procedure, optimization of instrument parameters for Pu isotopic analysis, and the analytical results from analyzing a broad range of spiked food samples will be presented.

About the Presenter

Kathryn Emanuele currently serves as a chemist in the Radiochemistry and Microbiology Section, Analytical Branch, Winchester Engineering and Analytical Center, FDA. She specialized in analysis of radionuclides in FDA-regulated products and has experience in various radiometric techniques including gamma ray spectrometry, gas-flow proportional counting, and liquid scintillation counting. She is also skilled in inductively-coupled plasma mass spectrometry and X-Ray Fluorescence (XRF) as well as various radiochemical separation techniques. Currently, she is developing and validating a number of radiochemical methods for the detection of radionuclides in foods per ISO standards.

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Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **152**   Type : **Poster**

Analysis of Radioactive Strontium in Food by Cerenkov Liquid Scintillation Counting

Thursday, 29 September 2016 10:00 (0:02)

Content

Hundreds of food samples are analyzed annually for radioactive strontium-90 (90Sr) at FDA's Winchester Engineering and Analytical Center (WEAC). Carried out under the FDA's food safety compliance programs, these laboratory analyses enable the FDA to assess the prevailing level of 90Sr in our nation's food supply and prepare to monitor any adverse changes of 90Sr concentration in the food supply as a result of a nuclear or radiological incident.

The current radiochemical method used for the detection of 90Sr is laborious, time-consuming, and potentially hazardous if not performed properly. It generates a high volume of mixed wastes containing organic solvent, strong nitric acid, and radioactive materials. These wastes are difficult to manage and expensive to dispose of. Besides these drawbacks, the method lacks the ability to detect another radioactive strontium isotope, i.e., 89Sr, a curial radionuclide necessary for radiological risk assessment in the event of a radiological emergency involving 89Sr.

In order to comply with green government mandates, improve operation safety, and expand the agency's radioanalytical capability, a novel, safer, quicker, and greener method was developed. This new method is based on solid-extraction liquid scintillation counting and was developed for the detection of 89Sr and 90Sr in a broad range of food. The new method differentiates between 89Sr and 90Sr in food and eliminates most of the hazardous wastes. Two types of Eichrom's extraction chromatography resins, i.e., Sr resin and DGA resin, with high affinity toward Sr and Y, respectively, were used for food analysis. The 89Sr and 90Sr (determined via its progeny isotope 90Y) were analyzed via Cerenkov liquid scintillation counting. The extraction yields for Sr and Y are determined by ICPMS and XRF, respectively. A preliminary study indicated that the new method provides not only a lower detection limit of 90Sr in food but also radioanalytical capability that is critically needed for responding to a radiological event that involves radioactive 89Sr.

About the Presenter

Stephanie Healey serves as a supervisory chemist in the Radiochemistry and Microbiology Section, Analytical Branch, Winchester Engineering and Analytical Center, FDA. She specialized in analysis of radionuclides in FDA-regulated products and has experience in various radiometric techniques including gamma ray spectrometry, gas-flow proportional counting, and liquid scintillation counting. She is also skilled in various radiochemical separation techniques. Currently, she is supervising a number of radiochemical method development and validation per ISO standards.

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Presenter(s) :   Ms. HEALEY, Stephanie (U.S. Food and Drug Administration)

Session Classification :   Radiochemical Techniques

Track Classification :   Radiochemical Techniques

Contribution ID : **153**   Type : **Oral Presentation**

Addition of Active Background Suppression for an International Monitoring System Gamma Detector

Thursday, 29 September 2016 14:40 (0:20)

Content

The International Monitoring System of the Comprehensive Nuclear Test Ban Treaty Organization includes a network of 80 field stations and 16 laboratories dedicated to the detection and analysis of airborne particulates to detect possible nuclear events that could indicate a violation of the Treaty. PNNL has operated a certified laboratory, USL16, since December 2007 with two commercial gamma spectroscopy systems (RL16-001 and RL16-002) and the recent addition of two very low-background gamma detectors housed in a new shallow underground laboratory (RL16-003 and RL16-004). Development of the two very low-background gamma systems, which utilize active background suppression, prompted application of the same technology to the above ground RL16-001 and RL16-002 detectors. The active background suppression or cosmic veto for each of the above ground systems consists of a single 76.2 cm by 76.2 cm plastic scintillator panel made of polyvinyl toluene (PVT) obtained from Eljen Technology (US). The cosmic veto panels are 5.08 cm thick and lay horizontally on an aluminum-framed radon enclosure that surrounds the commercial counting cave. The hinged-lid enclosure was modified to securely hold the 36 kg panel in place and protect the two photomultiplier tubes. The panel resides approximately 30 cm above the HPGe detector. As the majority of the cosmic muon flux is perpendicular to the earth's surface the single horizontal panel over the cave and HPGe detectors was expected to be the most cost effective background reduction. Two methods will be evaluated for generating the veto gating signal. In the first, the output from the two PMTs is combined and the signal input to a Canberra 2005 preamplifier with the preamplifier output feeding the Energy In on a Canberra Lynx DSP. The Lynx ICR output serves as the Gate-In to the Canberra Lynx which controls the HPGe detector. The second method involves sending the PMT output signals to a constant fraction discriminator (Ortec CF8000) which provides an input to an Ortec 416A gate and delay generator to produce the Gate-In signal for the HPGe Lynx. Based on previous experience, the methods should provide comparable performance though the second method, while requiring more NIM modules, is less costly. Overall a background reduction of between 30-45% over the $40 - 2500$ keV energy range is anticipated with the single veto panel. This should provide a significant improvement on minimum detectable activity (MDA) for each system.

About the Presenter

Mike Cantaloub is scientist working Pacific Northwest National Laboratory (PNNL) in the area gamma spectroscopy and advanced spectroscopic methods for radionuclide measurement in environmental samples.

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Presenter(s) :   Mr. CANTALOUB, Michael (PNNL)

Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **155**   Type : **Poster**

Determination of Fixed Radioactivity in LZ detector components

Tuesday, 27 September 2016 17:12 (0:02)

Content

LUX-ZEPLIN (LZ) is a near-future dark matter experiment that is on track to make an unprecedented spin independent cross section limit of 3 x 10-48 cm2 at 40 GeV/c2 for the Weakly Interacting Massive Particle (WIMP). To reach this target sensitivity, LZ requires careful control of intrinsic long lived radioactive isotopes (including 238U, 232Th, 40K, 60Co) in all structural materials and assembled detector components. In preparation for the construction phase, an extensive campaign of low background screening has been carried out for the purpose of choosing sufficiently radiopure materials. The majority of the work was completed using a suite of ultra-low background high-purity germanium detectors maintained by LZ collaborators, and located at two underground sites (Sanford Underground Research Facility in South Dakota and Boulby Underground Laboratory in the United Kingdom) and two surface locations (Lawrence Berkeley National Laboratory and The University of Alabama). Several detector types (p-type, n-type, BEGe, and well) ensure sensitivity to gamma rays within a wide range of energies (3 - 3000 keV) and allow measurements of concentrations required for LZ materials (~10 ppt). Due to high cross sections for (alpha,n) reactions and close proximity to the central active volume of xenon, the PTFE required neutron activation analysis to reach more stringent sensitivities of ~1 ppt. Other methods that are being used in place of or in addition to gamma ray spectroscopy include: inductively coupled plasma mass spectroscopy, alpha spectroscopy, and radon emanation studies. We will present results for the most important elements of the detector (Ti cryostat, PMT bases, PMT raw materials, PTFE, and other components) and demonstrate that all measurements are well below concentration limits required for LZ to meet its background target. We will discuss the current status of LZ material screening: all materials for building LZ have been identified and continued screening will focus on quality control measurements and determination of as-built levels of contamination in completed components.

About the Presenter

The work described in this abstract is part of a coordinated submission by the LZ collaboration. The presenter, Kelsey Oliver-Mallory, is a graduate student working on low background material screening for the LUX and LZ experiments at University of California Berkeley and Lawrence Berkeley National Laboratory. Her personal contributions to this effort include being part of the team setting up and maintaining the germanium detectors at Sanford Underground Research Facility, as well as creation of software for the autonomous liquid nitrogen control system used for detector cooling.

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Presenter(s) :   Ms. OLIVER-MALLORY, Kelsey (Lawrence Berkeley National Laboratory and University of California Berkeley)

Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **156**   Type : **Poster**

Development of a windowless multiwire proportional counting (MWPC) system for the measurements of the surface emission rate of alph- and beta- area sources

Wednesday, 28 September 2016 12:04 (0:02)

Content

A windowless multiwire proportional counting (MWPC) system is being developed to measure the surface emission rate of alph- and beta- area sources. We designed new anode plane and cathode plane to get the better electric field uniformity in the 250 mm x 200 mm of sensitive volume than that of the old MWPC at Korea Research Institute of Standards and Science (KRISS), which is being used as a national standard and shows an uncertainty level below 1 %. The operation high voltage of the alph and beta particles were determined based on the high voltage counting curve. In addition, the various detector characteristics are being studied with new MWPC. In this presentation, the preliminary results of the various detector characteristic will be shown. Additionally, the uncertainty estimation of the new MWPC will be discussed.

About the Presenter

I'm working at KRISS from Nov. 2015 and doing an upgrade of the MWPC system to measure the surface emission rate of alph and beta area source. Previously, I had developed a Time-Projection-Chamber, which is 3-dimensional tracking device, to measure the hadronic reaction with hadron beams at J-PARC in Japan. In addition, I designed the several scintillation and cherenkov detectors for the KURAMA spectrometer, which is the Kaon-meson spectrometer, in Japan.

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **159**   Type : **Oral Presentation**

IAEA proficiency tests for determination of radionuclides in sea water

Friday, 30 September 2016 10:40 (0:20)

Content

Six IAEA proficiency tests were organized between 2012 and 2015 to test the performance of participating laboratories in the analysis of radionuclides in sea water samples. These exercises were initiated to support IAEA Member States in sea water analyses of tritium, strontium-90 and caesium isotopes in relation to the accident at the Fukushima Daiichi nuclear power station, in March 2011, and subsequent contamination of the marine environment. A total of 59 laboratories from 35 countries participated in these six exercises including 13 laboratories from Japan.

Samples containing 5 L of filtered and acidified Mediterranean seawater spiked by the IAEA with the radionuclides were distributed to the participants, with the massic activities only known to the IAEA. The massic activities were traceable to a standard provided by a national standards laboratory. The combined massic activities in the exercise samples were lower than the natural activity level of K-40 in seawater. The H-3 massic activities for the exercise samples were in the order of 3 Bq/kg, while the Sr-90, Cs-134 and Cs-137 massic activities were between 0.1 Bq/kg and 0.4 Bq/kg.

The evaluation methodology took into account the accuracy, precision and trueness of the reported data and included in the evaluation both the combined standard uncertainty of the IAEA value and the combined standard uncertainty reported by the participating laboratories. A result must pass three statistical tests to be assigned the status "Accepted", otherwise it was assigned the status "Warning" or "Not accepted".

For H-3, practically all participants performed a distillation of the seawater samples, followed by liquid scintillation counting (LSC). Some laboratories performed an electrolytic enrichment after distillation (and obtained excellent results with small uncertainties). The direct measurements after distillation yielded slightly larger uncertainties. For Sr-90, most participants used gas-flow proportional counting (GPC) of chemically separated Y-90 as the analysis technique, with a minority that used LSC/Cherenkov counting. Chemical separation techniques used included precipitations of Sr-oxalate or Sr-carbonate, barium chromate precipitations, nitric acid precipitations, cation-exchange chromatography, Sr-extraction chromatography and direct liquid-liquid extraction of Y-90 with HDEHP. No significant difference between the performances of the chemical separation techniques is apparent. For Cs-134 and Cs-137, a majority of the participants measured the seawater samples directly with gamma spectrometry, while a minority of laboratories either used a pre-concentration technique (i.e. adsorption on ammonium molybdophosphate or hexacyanoferrate either copper, nickel or cobalt) to separate the caesium radionuclides from the seawater matrix followed by gamma spectrometry or they used a combination of the two techniques. No significant difference in the performance between the two techniques is apparent.

The evaluation of the individual exercise results showed that 43–78% of all reported results were "Accepted", while 13–43% of the individual measurement results were "Not accepted" with the remaining 6–17% having the "Warning" status. The "Warning" status will reflect cases in which the reported laboratory results were close enough to the assigned IAEA values, but its associated uncertainty was deemed to be either too small or too large.

In some exercises, significant negative biases of the combined participants' results for Cs-134 were observed, while, in general, there were no significant biases for H-3, Sr-90 and Cs-137. Coincidence summing is a problem for Cs-134 as it leads to signal loss and hence

underestimation of the activity levels for this radionuclide. It is clear from the results that some participants did not make a sufficient correction for coincidence summing.

About the Presenter

Arend Harms works as Radiochemistry and Reference Material Specialist in the Radiometrics Laboratory of the IAEA Environment Laboratories (NAEL) in Monaco since 2012. He is involved in the organization of proficiency test exercises, the provision of reference materials and the implementation of the IAEA Environment Laboratories Quality System.

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Presenter(s) :   Dr. HARMS, Arend (IAEA)

Session Classification :   Quality

Track Classification :   Quality

Contribution ID : **160**   Type : **Poster**

Rapid Detection of Processed Uranium in Food

Tuesday, 27 September 2016 12:02 (0:02)

Content

The US FDA maintains an active, robust program for routine monitoring of food for radionuclide contamination and stands ready to respond to emergencies. With on-going interest in increasing analysis capabilities, a focus of recent work has been application of isotope ratio mass spectrometry (IR-MS) to the determination of radionuclides in food. In this current study, a rapid, high-throughput method for detection of processed uranium in food was developed. This technique is particularly useful for uranium isotopes because the isotope ratios for processed uranium, as used for nuclear energy and weaponry, differ significantly from natural uranium. In response to an incident, the Agency may be in need of means to differentiate between natural and processed uranium. Since radioactive tracers and spikes are not used; non-radiochemical laboratories can perform this analysis. The method is intended for fresh fruit, vegetables, and dairy products, and 23 distinct categories of fruits, vegetables, and dairy have been examined to date with excellent results. Food can quickly and easily triaged into contaminated versus non-contaminated. For all non-contaminated products examined to date, the maximum deviation from known ratio is below 4 %. Sub-picogram quantities of U-235 can be detected in contaminated foods. Notable features include elimination of regulated nuclear material; i.e. non-radiochemical laboratories may perform this analysis, elimination of several extremely hazardous reagents e.g. aqua regia and hydrofluoric acid (HF), and the method was developed on a moderately priced, and widely used quadrupole ICP-MS. Traditionally fingerprinting studies are performed on expensive sector field mass spectrometers or thermal ionization mass spectrometer (TIMS). As developed, this method could be quickly implemented at many laboratories to increase emergency response capability

About the Presenter

Dr Shareef is a chemist at the US FDA

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Presenter(s) :   Dr. SHAREEF, Abdur-Rafay Shareef (US FDA)

Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **161**   Type : **Oral Presentation**

Laser Ablation Mass Spectroscopy of Polyethylene for U

Tuesday, 27 September 2016 09:40 (0:20)

Content

Large amounts of polyethylene (PE) are used as neutron shielding in low background radiation detectors. PE is a commodity material with many fabricators. Careful analysis of one lot or sample does not assure all the material needed will have adequately low U and Th levels. Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) is the most widely applied trace chemical assay technique, but it requires clean room support and extensive sample preparation. Laser Ablation Mass Spectroscopy (LA-MS) only requires a clean flat surface for analysis. However, experimental variables related to the equipment and samples make quantification difficult. This study compares conventional sample dissolution followed by ICP-MS of a heavy metal polyethylene (PE), ultra-high molecular weight polyethylene (UHMW) and high-density polyethylene (HD) to LA-MS. The Certified Reference Material (CRM) is for cadmium, strontium, and lead. the material mass ablated in a laser raster area is used to quantitate the LA-MS signal. In addition, the LA-MS behavior of lead (Pb) in the PE standard appears to be similar enough tot he behavior of uranium (U) in the standard that the LA efficiency of lead can be used to estimate the LA efficiency of the uranium. Results indicate that LA-MS compares well to dissolution followed by ICP-MS when the mass ablated and ion efficiency are determined for the specific ablation set up (laser type, power, frequency, focus, raster speed, etc.). LA-MS gave U concentrations within a factor of 2-3 of the more rigorous acid digestion followed by ICP-MS. U levels in the 10s to 100s of pg/g are reproducibly measured in the commercial samples. Primary sources of error are consistent placement of the sample after weighing and the small mass ablated i some measurements. The mass ablated quantification is compared to the volume ablated for selected samples.

About the Presenter

Mary Bliss, Ph.D., is a materials scientist who has been working in radiation detection and nuclear sciences since joining PNNL in 1990. She has a bachelor's degree in Ceramic Science from Alfred University, a master's degree in Ceramic Science from the Pennsylvania State University, and a Ph.D. in Solid State Science from the Pennsylvania State University. She worked in the composition control and applied research group at Coning while in college. Her Master's thesis was on the molten salt growth of piezoelectrics for sonar applications and her doctorate research was on the absolute infrared intensities of the silicon to oxygen bond in minerals. She worked briefly at General Electric Neutron Device where she was in a production support group that focused on materials acceptance, production problems, and contamination issues. Dr. Bliss and her team won an R&D 100 award and a Federal Laboratory Consortium Technology Transfer Award in 1999 for developing enriched lithium glass fiber neutron detectors. She is the author of over 60 open literature publications and government reports. She has worked on scintillators, wide bandgap semiconductors and a variety of sensors and materials.

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Presenter(s) :   Prof. BLISS, Mary (PNNL)

Session Classification :   Non-radiometric Measurements

Track Classification :   Non-radiometric Measurements

Contribution ID : **163**   Type : **Oral Presentation**

A comparative study of 129I content in environmental standard materials IAEA-375, NIST-4354 and NIST-4357 by Thermal Ionization Mass Spectrometry and Accelerator Mass Spectrometry

Monday, 26 September 2016 16:30 (0:20)

Content

With the increasing number of AMS laboratories around the world analyzing 129I, the need for readily available standard materials has increased in order to verify analytical methods. Iodine environmental measurements have consistently been validated in the literature by using the standard material IAEA-375, Chernobyl Soil, which is the only material with a certified 129I activity. IAEA-375 has not been available for purchase since approximately 2010. Having no standard available with a certified value for 129I has necessitated looking for other materials to use. A standard reference material that does not have a certified value does have the advantage of having been prepared to allow sub-sampling that is representative of the bulk standard. Two other standard materials that are available (NIST-4354, freshwater lake sediment and NIST-4357, ocean sediment) have certified activities for a variety of radionuclides but not for 129I. Previous literature studies have shown that 129I is present in these materials; however the data available in the literature has been insufficient to establish a consensus value for 129I. These materials have been analyzed at INL through two chemical separation and mass spectrometric analysis techniques. They involve a combustion method of the starting material followed by thermal ionization mass spectrometry, TIMS, and a leaching preparation for analysis by accelerator mass spectrometry, AMS. Both methods were validated via analyses of IAEA-375 for 129I and show good agreement with the certified activity of 1.7 mBq/kg for 129I; (1.8 mBq/kg by TIMS and 1.6 mBq/kg by AMS) with both sets of results within the 95% confidence interval of the certified value. Results will be presented for the 129I activity and 129I/127I isotopic ratio for environmental radioactivity standards IAEA-375, NIST-4354 and NIST-4357. The authors would like to suggest that these standards should be analyzed by other laboratories and consensus values determined. Once values are available, these would be used to fulfill the increasing need for 129I standard materials that are readily available.

About the Presenter

Dr. Matthew Watrous received his bachelor's degree in chemistry from Montana State University in 1995 and a bachelor's degree in chemical engineering in 2001. He received his doctorate degree from the University of Idaho in 2010. Dr. Watrous focused on thermal ionization mass spectrometry and increased production of ions specifically. Dr. Watrous has been working at the Idaho National Laboratory since 2003 in the area of rare isotope measurements through mass spectrometry. Dr. Watrous works with a group involved in thermal ionization mass spectrometry as well as accelerator mass spectrometry at Idaho National Laboratory.

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Session Classification : Non-radiometric Measurements

Track Classification : Non-radiometric Measurements

Contribution ID : **164**   Type : **Poster**

Improved Pressurized Marinelli Beaker Measurements of Radioactive Xenon in Air

Monday, 26 September 2016 12:04 (0:02)

Content

The international monitoring system (IMS) of the Comprehensive Test-Ban Treaty Organization (CTBTO) is in the process of implementing radioactive xenon monitoring at 40 locations across the globe. The goal is to be able to capture and measure radioactive xenon, which indicative of a detonation being from nuclear fission. The present systems capture air and separate the xenon from the bulk air prior to analysis. INL has shown that the Marinelli beaker geometry can be used for the measurement of radioactive xenon in unprocessed air. This was achieved through the construction of an aluminum Marinelli beaker geometry container for gamma ray analysis using high purity germanium crystal detectors. The Marinelli beaker geometry was evaluated for analysis of air that has been spiked with radioactive xenon. Limitations of the technique were the maximum pressure of 1000 psi and the attenuation of the aluminum container surface between the sample and the crystal. More pressure in the container would put more of the sample close to the detector. A material of construction that is less attenuating of the radioactive xenon gamma emissions would result in a higher efficiency for the geometry. A new Marinelli was designed and constructed from carbon fiber to address both the higher allowed pressure and less attenuating material of construction limitations. The newly constructed Marinelli can achieve higher pressures of 4000 psi and is built with a lower Z material of carbon between the sample and the detector. This has led to improvements in the reported efficiencies of the aluminum models. The experimental results of the carbon fiber Marinelli beaker are reported as the efficiency for four radioactive xenon isotopes; 131mxe, 133Xe, 133mxe and 135Xe. There is an improved performance for the carbon fiber Marinelli beaker geometry compared to the aluminum Marinelli beaker. The results are also compared to modelled expectations for the performance of the carbon fiber Marinelli beaker.

About the Presenter

Dr. Matthew Watrous received his bachelor's degree in chemistry from Montana State University in 1995 and a bachelor's degree in chemical engineering in 2001. He received his doctorate degree from the University of Idaho in 2010. Dr. Watrous focused on thermal ionization mass spectrometry and increased production of ions specifically. Dr. Watrous has been working at the Idaho National Laboratory since 2003 in the area of rare isotope measurements through mass spectrometry. Dr. Watrous works with a group involved in thermal ionization mass spectrometry as well as accelerator mass spectrometry at Idaho National Laboratory.

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Session Classification :   Radioactive Noble Gases
Track Classification :   Radioactive Noble Gases

Contribution ID : **166**   Type : **Poster**

Uncertainties in Monte Carlo calculated correction factors for true coincidence summations (TCS)

Wednesday, 28 September 2016 10:02 (0:02)

Content

Measurements of radionuclides are important in many areas, like environmental monitoring, treaty verification, process control in nuclear power plants and in the aftermath of a nuclear or radiological incident. Measurements of gamma emitting radionuclides can be done using e.g. high resolution gamma ray spectrometry. Calibrations in gamma ray spectrometry is often done using a mixed radionuclide solution. However, this empirical calibration approach will, for close geometries, result in a biased calibration (at least in some energy regions) due to coincidence summation (e.g. gamma-gamma coincidences and gamma-X coincidences). Moreover, measurement results may also be biased for radionuclides emitting gamma rays in coincidence as well as for radionuclides emitting gamma- and X-rays in coincidence. This systematic effect should, at least when significant, be corrected and the uncertainty in the correction should be quantified. The aim of this work was to estimate the uncertainties in Monte Carlo calculated correction factors for true coincidence summing (TCS), *ktcs*. Based on a detector model and a sample geometry, different parameters were changed in order to obtain a distribution in the *ktcs*, from which the standard uncertainty could be evaluated. First, a sensitivity analysis was done in order to exclude parameters, which do not significantly influence *ktcs*. After that a Monte Carlo approach using the data sampling scheme Latin Hyper Cube Sampling (LHS) was used. LHS was used since it reduces the number of calculations needed for the estimation of the mean value as well as for the standard uncertainty. The *ktcs* calculations were done with the Virtual Gamma Spectroscopy Laboratory (VGSL) software developed at the CTBTO. In this work TCS-factors and their uncertainties were calculated for 134Cs and then compared to empirical data. It was shown that the uncertainty in the calculated correction factor for the primary gamma ray was below 0.5%, which means it will not contribute significantly to the combined measurement uncertainty in an activity determination for e.g. environmental monitoring.

About the Presenter

Dr. Johan Kastlander has a PhD in experimental nuclear physics. Currently employed as senior scientist at the Swedish Defence Research Agency (FOI).

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Session Classification :   Radiometrics

Track Classification :   Radiometrics

Contribution ID : **167**   Type : **Oral Presentation**

Developing capacity for rapid response in the network of Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA)

Thursday, 29 September 2016 11:20 (0:20)

Content

The International Atomic Energy Agency has established in 1995 the Network of Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) with the objective to ensure that reliable data can be reported by the member laboratories in a timely manner in case of accidental or intentional radioactive contamination of the environment. In 20 years the network developed from 24 laboratories in 15 countries to 156 laboratories in 85 countries and continues to grow at a rate of up to eight laboratories every year. The IAEA supports member laboratories to improve, maintain and document the quality of the analytical data they produce in both routine and emergency situations. Professional networking, communication and capacity building through exchange of expertise are key to the development of the network and its participation in methodological development and IAEA reference material certification. Given the broad interests of member laboratories, the technical and strategic challenges are to support through network activities the development and use of methods improving precision, accuracy, sensitivity and response time. A group of ALMERA laboratories has also registered into the IAEA's Response and Assistance Network (RANET), which provides international assistance, upon request from a State, following a nuclear or radiological incident or emergency.

In the wake of the Fukushima Daiichi Nuclear Power Plant accident there was increased interest in rapid assessment methods. This interest was addressed by the IAEA through specific training courses, coordination of joint development and validation of rapid radioanalytical methods and organisation of customized proficiency tests (PTs). The yearly PTs involve six environmental and food samples, typically prepared by spiking natural matrix materials with anthropogenic and natural radionuclides. The radionuclides and levels are chosen so as to be relevant to the measurement of environmental radioactivity of different origins and to continuously challenge the participants. Radiochemical and counting techniques are comprehensively tested, with a reporting time of the order of several months. In addition, rapid reporting is requested for selected radionuclides and samples three days after the registered reception of the set of PT samples. This paper analyses the performance of the network laboratories in these rapid measurements over a period of three years, points out the strengths and areas needing improvement and describes the way the latter are addressed through methodological guidance and training.

About the Presenter

Dr. Iolanda Osvath works as research scientist in the IAEA Environment Laboratories in Monaco. She is the coordinator of the ALMERA network and section head of the Radiometrics Laboratory, which operates a low-level underground counting facility in Monaco. Her research interests include marine radioactivity measurement, modelling and assessment, radiotracer applications to marine studies, low-level and underwater gamma-ray spectrometry.

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Presenter(s) :   Dr. OSVATH, Iolanda (IAEA)

Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **168**   Type : **Oral Presentation**

INVITED TALK: The potential detection of low level aerosol isotopes from new civilian nuclear processes

Thursday, 29 September 2016 13:40 (0:20)

Content

As the world faces a challenging future in maintaining the commercial availability of radioactive isotopes for medical use, new methods of medical isotope production are being pursued. Many of these are small in size and could effectively operate continuously. With the potential for much shorter retention times, a new suite of isotopes may soon be found in the environment. The authors estimate that low-level isotopes of gas/volatile origin could be detectable as compared to those released in nuclear reactor operations.

About the Presenter

Harry Miley is the chief scientist of PNNL's Nuclear Explosion Monitoring Program, which for over twenty years has been focused on monitoring Earth's environment for radionuclide debris of nuclear weapons indicating a violation of a treaty or agreement. The NEMP program serves the National Nuclear Security Administration, the Department of Defense, and the US State Department with technology developments, scientific analysis of monitoring network data, and technical advice related to the negotiation of the Comprehensive Nuclear Test Ban Treaty, or CTBT. Recently, Dr. Miley has helped to form the corps of on-site inspectors for the CTBT through training of new inspectors and by leading the radionuclide component of the inspection team in field training exercises. Dr. Miley has also been a lifelong contributor to neutrino and dark matter research. He helped found and organize the Majorana collaboration, a multi-institution experiment to measure the mass of the neutrino through 76Ge double-beta decay. Dr. Miley received his B.S. in Physics from South Carolina College, the honors college of the University of South Carolina, in 1982; and his Ph.D. in Physics from the University of South Carolina in 1987.

Primary author(s) :   Dr. MILEY, Harry (Pacific Northwest National Laboratory)

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Presenter(s) :   Dr. MILEY, Harry (Pacific Northwest National Laboratory)

Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **169**   Type : **Poster**

Development of an underground multidimensional gamma-spectrometer

Thursday, 29 September 2016 15:22 (0:02)

Content

Multidimensional gamma-spectrometry is a powerful technique for making low-level nuclear measurements in support of research studies as varied as the movement of environmental radioactivity to the nature of meteorites. A high-sensitivity system is being developed that comprises of two Broad Energy Germanium (BEGe) detectors surrounded by a segmented sodium iodide (NaI) shield situated in the underground low-background laboratory at Pacific Northwest National Laboratory (PNNL). The high-performance BEGe detectors combine the spectral advantages of low energy and coaxial detectors, with an energy range from 3 keV to 3 MeV and optimized energy resolution and efficiency. Novel coincidence measurements can be performed using the dual BEGe and NaI configuration, including the measurement of radionuclides that emit two or more gamma-rays in cascade (e.g. 60Co) or are positron emitters (e.g. 22Na, 26Al). Although detection efficiency is reduced using this configuration, selection of coincident or anti-coincident gamma-energies produces significant background reduction by a factor of up to 200. The NaI shield also enables the Compton suppression of scattered gamma-rays, and accurate measurement of fission products such as 111Ag, 91Y and 115Cd in the presence of multiple interferences. Powerful digital multichannel analyzer (MCA) electronics enable the simultaneous operation in both non-coincidence, coincident and Compton suppression modes, together with the acquisition of conventional histogram and high-fidelity time-sequence data. This maximizes the data obtainable from non-destructive measurement of environmental samples.

About the Presenter

Dr Jonathan Burnett is a senior scientist at PNNL with over 13 years' experience in environmental radioactivity from natural, civil and military sources. Throughout his career he has been extensively involved in supporting nuclear forensics and the Comprehensive Nuclear-Test-Ban Treaty. His research interests include the application of advanced gamma-spectrometry techniques for low-level radionuclide detection. This has included the development of next-generation Compton suppression, cosmic veto and coincidence systems.

Primary author(s) :   Dr. BURNETT, Jonathan (Pacific Northwest National Laboratory)

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Presenter(s) :   Dr. BURNETT, Jonathan (Pacific Northwest National Laboratory)

Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **170**
Type : **Oral Presentation**

ULBS, CES and Environmental Measurements at Laboratorio Subterráneo de Canfranc (LSC)

Tuesday, 27 September 2016 16:30 (0:20)

Content

The Laboratorio Subterráneo de Canfranc (LSC) is the second largest underground laboratory in Europe. LSC is located under the central Pyrenees in Spain. At LSC an number of experimental facilities are installed and under commissioning to search for rare events such as dark matter and neutrino-less double beta decay. More research is carried out in geophysics and life in extreme environments. To support the construction of the experiments at the LSC, an Ultra-Low Background Service (ULBS) and a Copper Electro-forming Service (CES) were created.

The measurement technique employed at the ULBS is gamma spectroscopy with HpGe detectors. Seven HpGe detectors are working at LSC. Improvements in the design of the shielding and the construction of an anti-radon system to lower the background of the detectors are being implemented. At LSC a radon abatement system, which produce radon-free air at 1 mBq/m3 is working. The ULBS facility at LSC will be reviewed.

The main goal of CES Service at LSC is to obtain high-purity copper pieces. The electro-forming of copper pieces has been reported to be an effective way to obtain high-purity copper needed for the construction of ultra-low-background radiation measurements devices. At present at LSC the ANAIS experiment is using electro-formed copper made on site. The techniques and results of the electro-formed copper pieces obtained at the CES will be presented. To improve even further the quality of the pieces produced, a new electro-forming set-up inside LSC underground clean room is planned. At LSC the copper to make electro-formed pieces is stored underground to avoid cosmogenic activation. A number of proposals have been submitted to LSC to study the radioactivity and the mechanical properties of electro-formed copper.

Radon and environmental measurements at the LSC are presented. Series of results along with their possible correlations are investigated.

About the Presenter

Chemical Technician at the Canfranc Underground Laboratory (Oct 2009 – nowadays), skilled in all aspects of chemical engineering including R&D copper electroforming process, clean room environments and dangerous waste management and its regulations. In overall charge of the Chemical Area, setting up and conducting chemical tests and analyses using different techniques, developing rules and safety guidelines and performed preventive and corrective maintenance of laboratory equipment. As the Clean Room Manager, supervising its construction, use and maintenance as well as teaching external users in these critical environments. Also in charge of Dangerous Waste Management, controlling its generation, storage and its ultimate disposal, and interacting with regulatory agencies to ensure regulatory compliance. Copper Electroforming Facility Manager, preparing the installation and controlling the conditions to obtain ultra-pure copper pieces according to the requests from external orders.

Involved in preparing samples, making different analyses and giving results related to radioactive & chemical environmental control, in collaboration with LABAC (University of Zaragoza).

Providing permanent technical support and assistance to external users and companies in area of responsibility.

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Co-author(s) :   Dr. BANDAC, Iulian (Laboratorio Subterraneo de Canfranc (LSC))

Presenter(s) :   Ms. BORJABAD SÁNCHEZ, Silvia (Laboratorio Subterráneo de Canfranc (LSC))

Session Classification :   Applications

Track Classification :   Applications

Contribution ID : **171**   Type : **Oral Presentation**

INVITED TALK: Repurposing Existing Portal Monitor Infrastructure

Thursday, 29 September 2016 10:40 (0:20)

Content

Radiation Portal Monitors (RPM) have been installed throughout the world to detect the transportation of illicit nuclear material. This network bases its alarm decisions on local radiation environments. Transient radioactivity, such as is present in precipitation events, impacts RPMs' sensitivity to hardwired quantities of threat materials. This challenge can be viewed as a feature in another endeavor: accounting of environmental releases of radioactivity. Existing RPM infrastructure can be used to directly study the time-dependent concentration of certain isotopes in clouds.

About the Presenter

Dr. Livesay received a BS in Physics from the University of Texas at Arlington and a PhD in Applied Physics from the Colorado School of Mines. He left the accelerator world and entered nuclear non-proliferation in 2007. Since then, he has traveled extensively for DOE's Nuclear Smuggling Detection and Deterrence Program (NSDD) – formerly Second Line of Defense (SLD). His first duties included the development and distribution of software designed for the analysis of RPM data. This early work formed the basis of his work published in the Journal of Environmental Radioactivity (JEnvRad), in 2014. Dr. Livesay has had the opportunity to work on many scientific issues related to the generation of radiation background, both static and transient. In 2012, he co-founded Mason Livesay Scientific and serves to this day as its Chief Scientist.

Primary author(s) :   Dr. LIVESAY, Ronald J. (Mason Livesay Scientific)

Co-author(s) :   Mr. GUZZARDO, Tyler (International Atomic Energy Agency)

Presenter(s) :   Dr. LIVESAY, Ronald J. (Mason Livesay Scientific)

Session Classification :   Special Session: Monitoring Networks

Track Classification :   Special Topic: Monitoring Networks

Contribution ID : **172**   Type : **Oral Presentation**

INVITED TALK: Emerging social, scientific and legislative triggers for the application and development of LLRMT resolving NORM issues

Friday, 30 September 2016 13:40 (0:20)

Content

For precise activity measurement of NORM, innovative systems must be used to comply with the scientific and legislative requirements in the norm field. Additionally, accurate and reliable measurements are needed to help the industry in the selection of adequate raw materials for safe processing and products which comply with the radiation protection requirements. Precise measurements of natural radionuclides in NORM waste will also support a reduction in disposal costs through optimisation of the NORM material processing. This talk focuses on current and emerging social, scientific, legislative, economical and metrological requirements for NORM measurements. To ensure correct and accurate measurement, all measurement systems must be calibrated in a traceable way with calibration standards and reference materials that are adapted in an appropriate manner to the real composition and geometry of measured materials. Special consideration is given to low-level radionuclide metrology and low-level activity measurement techniques in the NORM field with adequate measurement time and measurement uncertainties.

About the Presenter

Franz Josef Maringer, Physicist, Section Head Ionising Radiation and Radioactivity at the Federal Office of Metrology and Surveying (BEV), Austria, Professor for Radioecology and Radiation Measurement at the University of Technology Vienna (TU Wien) and University of Natural Resources and Life Science Vienna (BOKU), Austria, Vicepresident ICRM, Honorary Board Member of the Austrian Radiation Protection Association (ÖVS), Scientific Co-ordinator if the EMRP joint research Project MetroNORM

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Session Classification : Special Session: Metrology of NORM

Track Classification : Special Topic: Metrology of NORM

Contribution ID : **183**   Type : **Oral Presentation**

INVITED TALK: Issues associated with the Metrology of TENORM

Friday, 30 September 2016 14:00 (0:20)

Content

Though the understanding of the generation and impacts of Technologically-Enhanced NORM (TENORM) has increased over the last decade, the differing regulatory frameworks within the United States add complexities when assessing and managing TENORM on a national basis. There is no federal TENORM statute, and the United States Environmental Protection Agency (EPA) regulatory authority is limited to addressing only certain aspects of TENORM via several federal laws. In practice, the management and regulation of TENORM falls primarily to the individual states; numerous states have promulgated state specific TENORM regulations. These varying regulations and a lack of a consistent definition of NORM/TENORM complicate the assessment and measurement of TENORM. This presentation also addresses some noted issues associated with TENORM metrology, based on years of experience.

About the Presenter

Kristen Schwab has been with Washington State's Department of Health, Office of Radiation Protection for 15 years and has worked in the field of health physics for 25 years. The Office of Radiation Protection oversees the use of radioactive materials and x-ray machines within the state, as well as radioactive air emissions, radioactive environmental monitoring, and radiation emergency response actions. Kristen has been working for the Waste Management Section of the Office of Radiation Protection for the last 9 years. She is the project manager for three mineral processing facilities in varying stages of TENORM decommissioning, the Low-Level Commercial Radioactive Waste Site, and a waste processing facility. She also provides technical support to a decommissioning uranium mill. Kristen has extensive experience in licensing and inspecting facilities that use radioactive materials, policy interpretation and compliance related issues, as well as developing, implementing, and overseeing site characterizations and decommissioning. Kristen received her Bachelor of Science degree in Radiological Health Physics from University of Lowell and Master of Science degrees in both Environmental Engineering and Radiological Health Physics from Oregon State University. Prior to working for the Washington State, Kristen performed research at Pacific Northwest National Laboratory, worked as nuclear power plant health physicist, and worked in an environmental laboratory testing for radioactive contaminants.

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Session Classification :   Special Session: Metrology of NORM

Track Classification :   Special Topic: Metrology of NORM